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MAGAZINE OF WORLD ASTRONAUTICS

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review of Space Legislation . .p. 15
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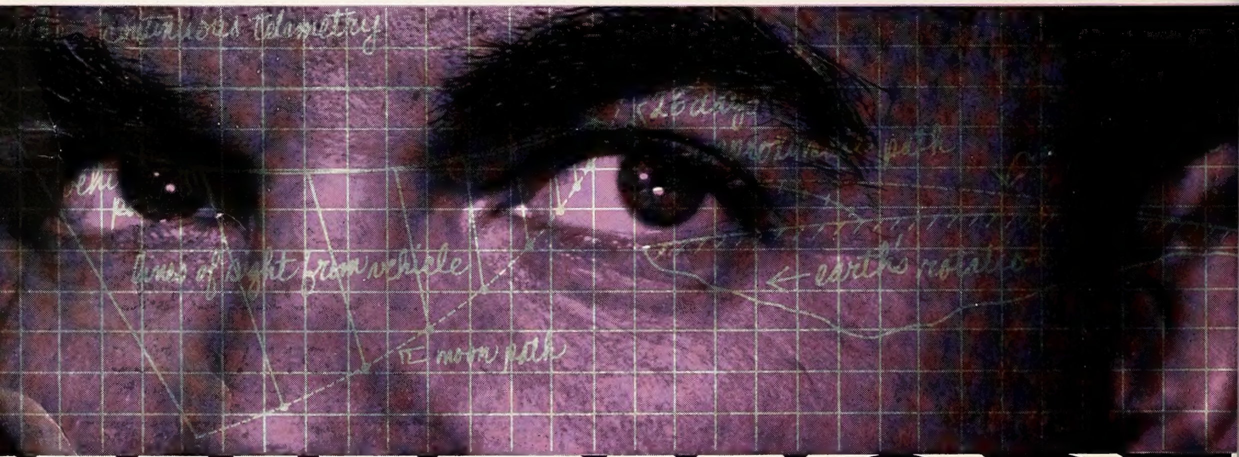

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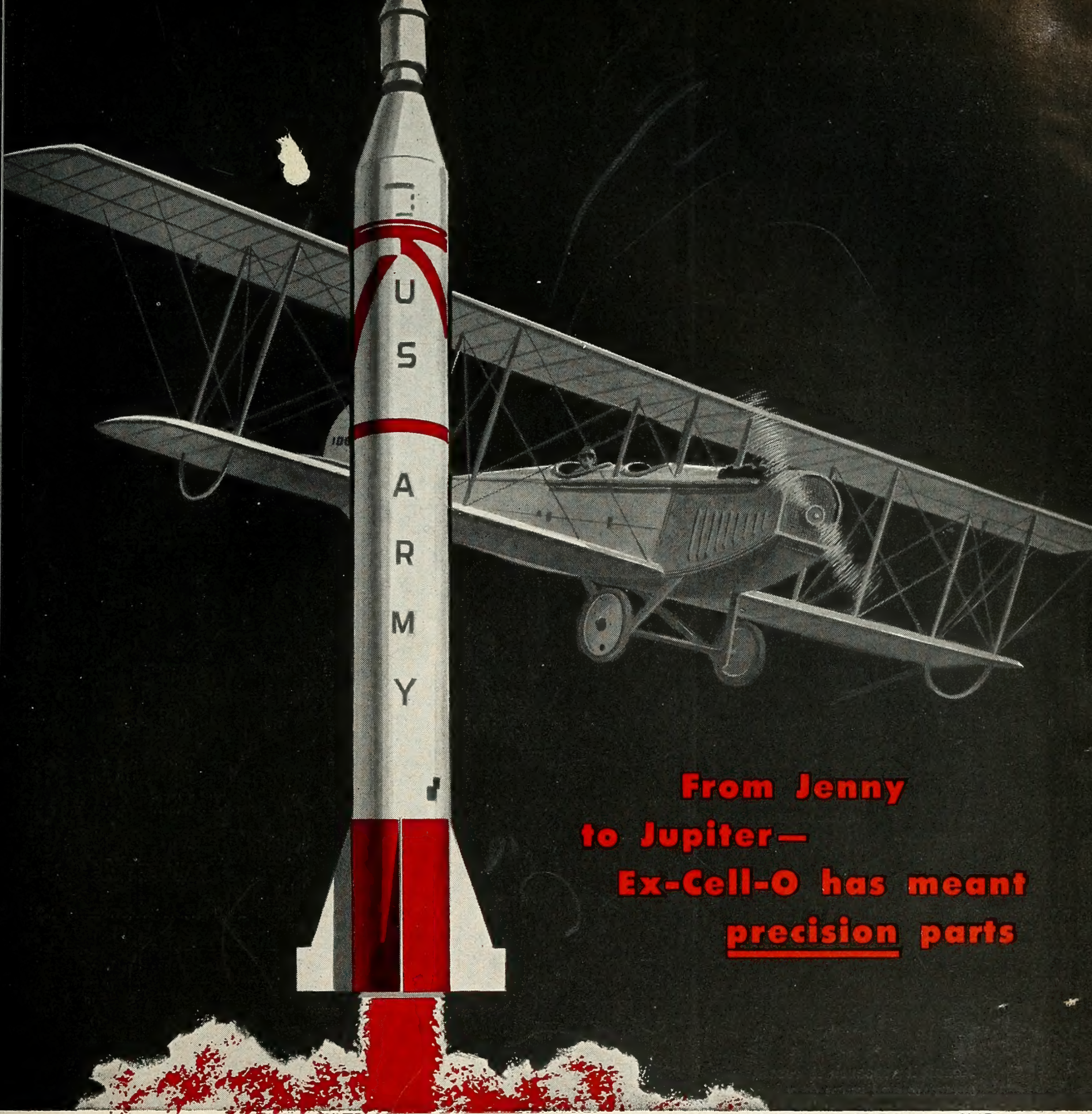
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58-17

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missiles and rockets

MAGAZINE OF WORLD ASTRONAUTICS

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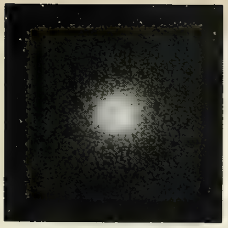
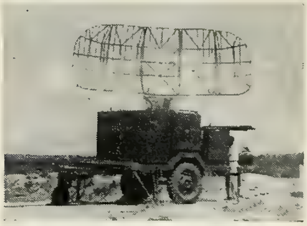
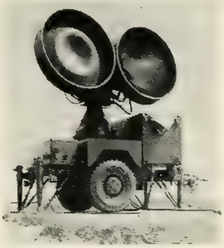


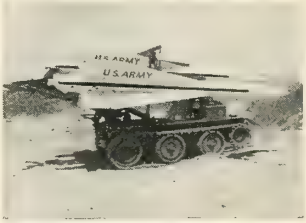
COVER: New U.S. radio telescope will bring star clusters like this closer. Story on p. 14.



THE *Hawk* defends against low-level attack. This is acquisition radar of Raytheon system.



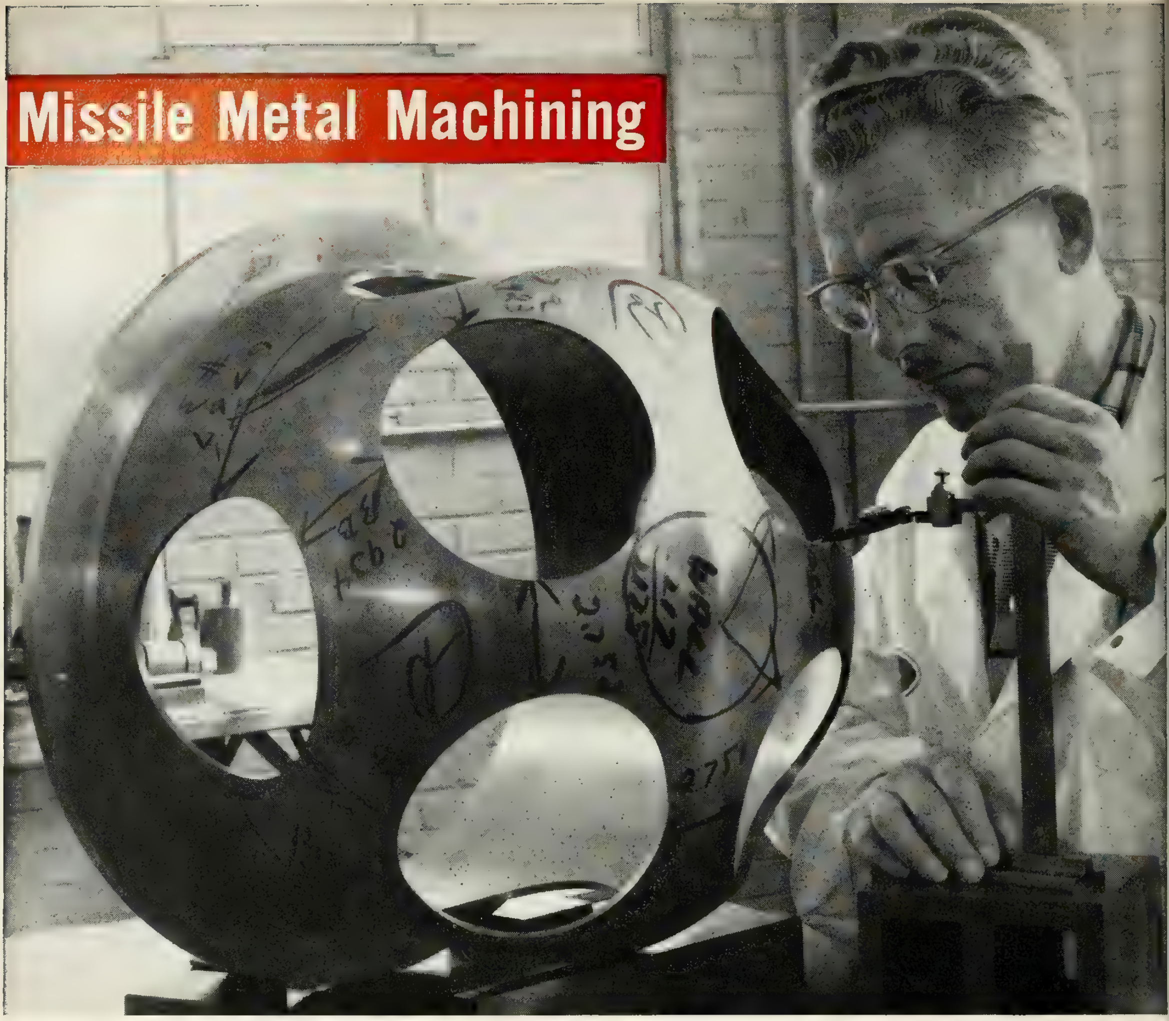
HIGHLY MOBILE ground equipment allows *Hawk* units to keep up with fast moving troops.



TRACTOR DRIVEN Army missile loaders can quickly transfer three *Hawks* simultaneously.

RAYTHEON has been awarded an additional $5 million for *Hawk* engineering.

Missile Metal Machining



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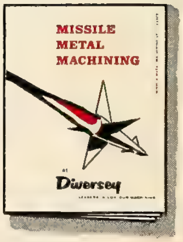

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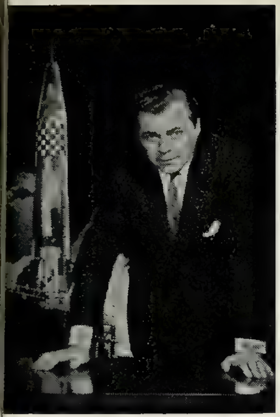

In My Opinion . . .

. . . there's no doubt that industry has made great advances in the last two years in the field of big engines. And there's no doubt that NASA's program for a big single-chamber million-and-half pound engine will be carried out successfully. But engine designers are facing intricate problems in propellant flow systems. An example of the difficulties is illustrated by Rocketdyne's efforts to scale up the current 160,000-pound thrust power plant. By simply modifying the combustion chamber it was possible to jack the thrust up to 300,000 pounds although a special pressure system had to be devised that would not be practical in a flight system. Rocketdyne is still working on a turboprop flow system for this new engine.

The estimated development time for the new million-and-half pound single-chamber rocket—from four to six years—clearly indicates the urgent need for continuing the parallel ARPA program for the clustered million-and-half unit—which may be ready for static test 11 months from now and flyable less than two years from now.

Certain "break-throughs" in the area of clustering big liquid engines have been reported and reliable sources have confirmed that both component tests and wind tunnel tests have proven the soundness of this engineering approach. The big eight-unit clustered powerplant may be employed for a variety of military and scientific space vehicles, and—in many cases—will present an even better approach to getting heavier payloads into space since the individual engines may be dropped en route like individual stages in a conventional step rocket. The soundness of this technique certainly was demonstrated in the recent *Atlas* satellite shoot. Also, the discarded units may be recovered if necessary.

It is obvious that the research and engineering which industry and government agencies now are putting into big engine development points to a new trend: there will be a need for both clustered units and single-chamber units. And we have the know-how to do both jobs.

The fact that the one program is the responsibility of ARPA and the other is carried out by NASA doesn't necessarily mean that the clustered unit will be used for military vehicles exclusively and the other one for "peaceful" or scientific missions. The important thing is that we fully understand that there is an established requirement for the two powerplants.

In view of this fact we consider it rather discouraging that certain "experts" in Washington and elsewhere are putting the pressure on to kill the ARPA engine program. It is difficult to grasp how supposedly intelligent planners at times can be so nearsighted, so completely ignorant of the logic in a sound engineering approach. ARPA deserves the most extensive and wholehearted backing in this program. Already its planners have demonstrated good and sound judgment. It was ARPA that got our lunar program off the ground in less than two weeks. It was ARPA that undertook the *Atlas* satellite program.

Let ARPA complete the big cluster job—and let's keep political bickering away from the research and engineering required to put us ahead in the space race.

Erik Bergaust

NOTABLE ACHIEVEMENTS AT JPL...

PIONEERS IN MOBILE MISSILE SYSTEMS

The "Sergeant's" excellent mobility characteristics, including the ability to operate under conditions of winter snow, ice, mud, desert sand and heat, significantly extend the capabilities of the system for close support of a ground command in our modern United States Army. The ease of operation and handling permits the weapon to be unloaded from airplanes or landing craft and be ready for firing with a minimum of preparation.

The system concept demonstrated in the "Sergeant" has permitted excellent mobility and speed of operation to be attained. The requirements of the Army have been stressed, resulting in outstanding characteristics of the weapon meriting the title of "America's first truly 'second generation' surface-to-surface tactical missile."

The responsibility for accomplishing this important achievement has been placed on JPL by the United States Army Ordnance Missile Command.

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washington countdown

Top priority has been given . . .

to Air Force's WS-199 *Bold Orion* (m/r, Dec. 1, p.11) following recent successful launches of the Lockheed and Martin versions. AF wants an available air launched IRBM of 1,000 mile range within two years for adaption to more B52G and B58 bombers. Budgeting of aircraft to handle the missile should approximate $2 billion in FY 1960.

Russian ICBM guidance . . .

apparently is terrific, according to a report made to President Eisenhower by RAND Corp. During next 18 months, Soviets reportedly will have 300 ICBMs of 50 per cent reliability with half that number able to land within three miles of target. First full range *Atlas* shot reportedly had a 30 mile impact area.

The triple firing . . .

at Cape Canaveral—*Polaris, Thor* and *Atlas*—which was scheduled for the tag end of 1958 will be the last ballistic launchings over the Atlantic Range for some time. The substitution of ballistic computers plus holiday-absent technicians is responsible for delay.

Standing space committee . . .

memberships will be announced soon. These will be the first standing committees on space and science. Sen. Lyndon Johnson undoubtedly will head the Senate committee. Reps. Paul Kilday of Texas and Overton Brooks of Louisiana are still leading contenders for chairman of the House committee. Johnson recently announced appointment of Kenneth E. BeLieu as staff director of the Senate group.

Soviet military buildup . . .

will continue during 1959. Although USSR military budget is reduced to $24 billion, a new $18 billion industrial expansion fund is expected to provide additional funds for space and nuclear research. The Soviet "visible military budget," while some $13 billion less than the U.S., still approximates the U.S. budget in purchasing power.

AIA's report for 1958 . . .

stresses that the industry made radical changes in organizations to supply the demands of the new space era. The report notes that companies previously known only as airframe manufacturers have become leaders in propulsion, guidance and atomic energy applications. Sales for the aircraft and missile industry were estimated at $11.8 billion, approximately the same as in 1957, with sharp reductions in the production of military aircraft offset by increased expenditures for missiles and space vehicles. AIA predicts that barring a national emergency, 1959 expenditures for aircraft and missiles will remain about the same.

Small businesses' . . .

slice of the defense melon should be larger than the 3.7 percent of total prime contract dollars they got in 1958, according to the Senate Small Business Committee. The committee rejected the Pentagon argument that the decline was due to changeovers to items small business cannot provide, and pointed out that defense "procurement procedures . . . militated against small business."

A recent poll . . .

indicates that one out of every three Americans either do not know what satellites are, or have never heard of them. Taken eight months after Russia successfully orbited *Sputnik I*, the University of Michigan Survey Research Center poll reported that one out of every two Americans consider satellites as either a scientific achievement or as an element of Soviet competition; one in five view satellites in terms of future potentials, such as space platforms or tickets to the moon; and one in three were either misinformed or uninformed.

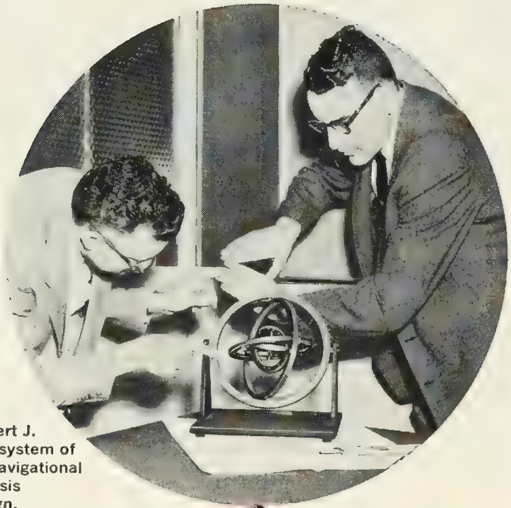
50,000 pound thrust tests . . .

were carried out in static trials of the Navy's packaged liquid rocket, as reported last week in m/r. The air-to-air tests were of a much smaller power plant using a *Sparrow III* missile. Reaction Motors Division of Thiokol is developing the engine under the Guardian program.

Circuit Development Group Leader Ralph Wolcott (left) considers future changes in computer output unit for bombing—navigational systems.

Ground-floor opportunities in

COMPLETELY INTEGRATED B-70 WEAPON SYSTEMS *at* IBM



Project Engineer Robert J. Cantwell (left) uses a system of gimbals to describe navigational problems in the analysis of a new system design.

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Staff Engineer William Howard (center) reviews gearing accuracy requirements of test equipment with electronic circuit designers.

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MILITARY PRODUC

industry countdown

Latest *Snark* contract . . .

may well be the last for the giant intercontinental pilotless bomber if the current downgrading of air-breathing missiles, as the results of budgetary considerations, continues. First to go was the *Goose* decoy and the *Regulus II*. Next to get the economy axe may be the *Matador*, leaving only the *Snark* as a major air-breathing missile system. New *Snark* award of $50 million will cover production of the missile through December 1960. The production figure, for operational weapons plus spare parts and ground support equipment, includes a $20 million letter contract awarded last September.

Bomarc terminal guidance . . .

systems, the most expensive single item aboard the missile, has received additional production funds in a new $10 million contract awarded by Boeing to the Air Arm Division of Westinghouse Electric Corp. This brings the total value of *Bomarc* guidance systems contracts to Westinghouse to approximately $60 million. Existing contracts will run target seeker production through 1960. Westinghouse is also developing the target seeker guidance system for the advanced *Bomarc*-B 400-mile area defense missile.

Battlefield surveillance . . .

by unmanned missiles is the goal of a development program by the Army and Republic Aviation. Designed to replace the faithful Grasshopper light aircraft for gathering information of enemy positions and movements, a drone which is a later generation RCAT (aircraft target missile) is in the final stages of development at Republic. The drone, known as the *Swallow* SD-4, is launched by small rocket motors and is sustained in flight with a turbojet engine. Republic's Signal Corps development contract is valued at $25 million.

Surveys of *Minuteman* transport . . .

equipment and types have been conducted by the Air Force, Boeing and consultants in a logistical investigation of the system. Teams have covered a broad area of the central United States evaluating roads, bridges and railroads in an effort to determine the types of equipment best suited to the prevailing conditions of the transportation medium.

Combat-proven *Sidewinder* . . .

already proven to be a highly accurate weapon system, will get an improved guidance unit. A $1.86 million contract from Bureau of Ordnance to Motorola Military Electronics Division calls for development of the new system. Work will be performed at Motorola's Western Military Electronics Center in Phoenix.

Guggenheim Foundation seeks . . .

outstanding students to receive Fellowships for graduate study in astronautics, rockets, jet propulsion and flight structures. Eighteen to twenty Fellowships will be given for study during 1959-60 at the Daniel and Florence Guggenheim Jet Propulsion Centers at Princeton University and California Institute of Technology.

NASA's MIS capsule . . .

prime contractor will be selected next month, probably receiving a development contract before the first of February. First man-in-space capsule is expected to be carried aloft in the nose of an *Atlas* D missile with the first animal test flights with this configuration anticipated by the end of 1959. Earlier flights will use *Thor* and *Jupiter* for transporting animals on ballistic flights from Cape Canaveral and Vandenberg AFB (similar to flight of monkey Gordo in *Jupiter*).

ARPA and NASA MIS programs . . .

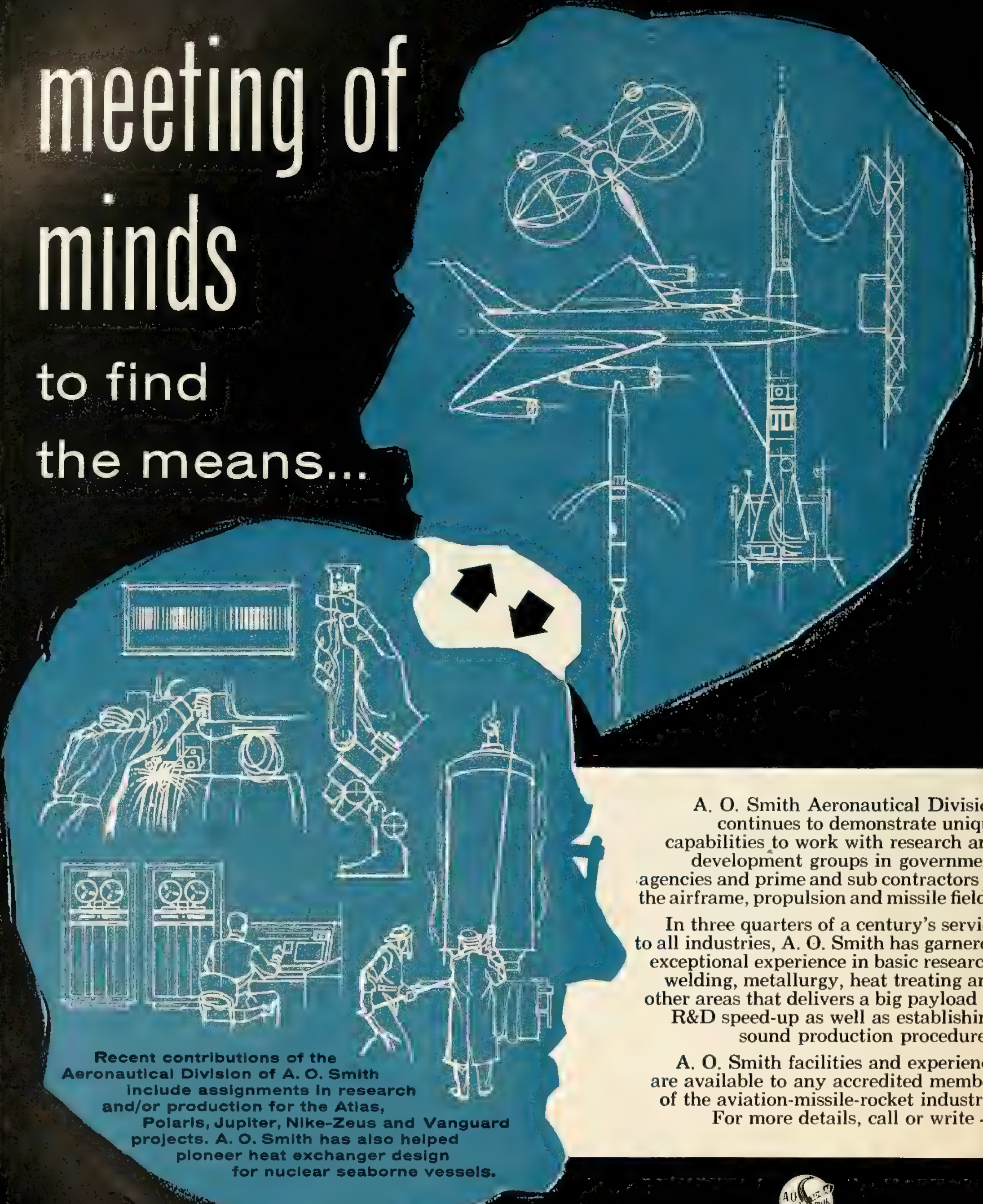
although dual coordinated efforts, are essentially two separate distinct projects. ARPA refers to its man-in-space program as Project *Discoverer* while NASA is now calling its efforts Project *Mercury*. ARPA will send animals into polar orbits from Vandenberg and attempt to recover them. First using *Thors* and later *Atlas* as boosters, project will also investigate feasibility of reconnaissance satellites. Meanwhile NASA's Dr. T. Keith Glennan has announced that success of Project *Mercury* is several years away. Dr. Glennan did not elaborate in detail whether the success of Project *Mercury* would be the first orbiting of man and recovery or whether he was referring to the establishment of manned permanent satellites. Roy Johnson, ARPA chief, stated meanwhile that Russia would probably beat us in placing man in space.

Beryllium rolling mill . . .

facilities will be expanded by the construction of new facilities to house additional cold strip mill equipment and to increase machining capacity for billet and slab milling at Brush Beryllium Co. in Cleveland.

meeting of minds

to find the means...



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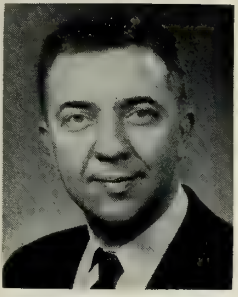


Dr. James A Van Allen awarded AAS Space Flight Award for his experiments.

Radiation Can Be Avoided

Van Allen advocates polar launchings; proposes that two radiation belts be mapped by 100-pound payload satellite

by Norman L. Baker

WASHINGTON—Manned space flights can avoid the radiation belts which encircle the earth if flights originate from polar latitudes. This is the opinion of Dr. James A. Van Allen of the State University of Iowa whose instruments aboard U.S. space probes discovered the radiation belts.

Dr. Van Allen last week summarized 1958 satellite and space probe radiation experiments before the fifth annual meeting of the American Astronautical Society.

The meeting was held in conjunction with the 125th session of the American Association for the Advancement of Science. The AAAS meeting saw thousands of scientists attending some 300 sessions.

Dr. Van Allen, who was presented with the AAS Space Flight Award, reported that instruments aboard the *Pioneer III* lunar probe indicated that two belts—varying in length and thickness and in distance from the earth and from each other—exist in the earth's magnetic field. The belts extend for equal distances north and south of the equator, diminishing into insignificance in the polar regions.

Van Allen said that his mapped boundaries of the belts were based on data obtained from the *Pioneer III* instruments. He said more extensive experiments would be needed to substantiate these findings. The first belt is about 2,000 miles thick starting at 1,400 miles out. The second belt, approximately 4,000 miles thick begins at 8,000 miles.

The areas between the first belt and the earth and between the belts and beyond is considered relatively safe for prolonged space operations. No radiation problems will be encountered for flights below 500 miles altitude.

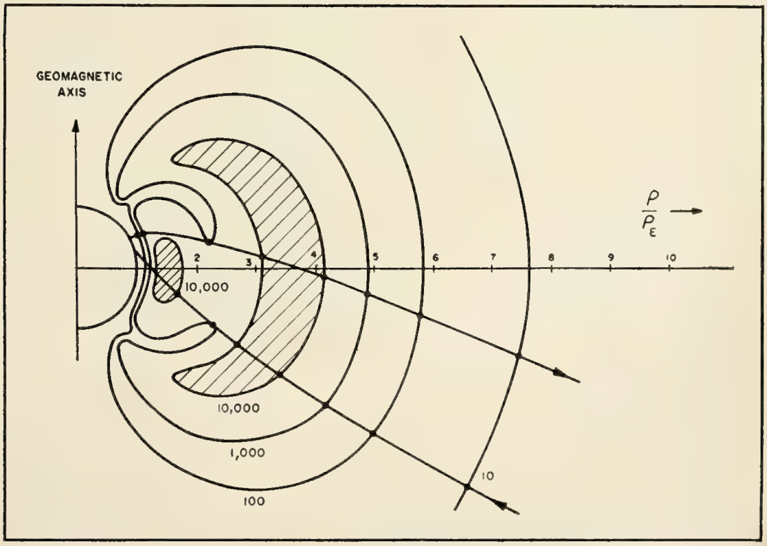
• **Best position**—Van Allen said the best position for extended manned satellite operations would be between the belts at approximately 6,000 miles altitude. In this region radiation was measured at .2 to .3 roentgens per hour. This 4,600-mile wide "radiation free" belt would be ideal for near-circular orbits.

Launch into such an orbit could be made from Vandenberg AFB or from Ft. Churchill, Canada in an northerly direction. Lunar or interplanetary flights could be made by launching directly out into space over the poles from either of these bases.

Each of the two distinct radiation zones are concentric with the earth's core and have identical intensity peaks. The hearts of maximum intensity—7,600 miles apart—the first at 2,400 miles out and the second at 10,000 miles—was measured at 25,600 counts per second.

The maximum intensity count is equivalent to about 10 roentgens per hour if particles are electrons and about 100 roentgens if protons. The type of particles have not definitely been determined. Van Allen thinks it highly unlikely the particles are protons and is firmly convinced, at least, that the particles in the outer rings are electrons. Dr. S. Fred Singer of the University of Maryland, has hypothesized (m/r, Sept. 1, p. 23) that the particles are protons.

The high intensity recordings mean



CROSS-SECTIONS of the two radiation belts—shaded areas—plotted from measurements obtained during *Pioneer* probe of Dec. 6-7. Arrowed lines show the flight path of the payload. Dots represent intensity.

that an unprotected man could not survive long after having received more than 45 hours exposure within either belt. Van Allen said that a space passenger could—in a fast dash—penetrate the belts without any undue hazard. Exposure in the 10 or 100 roentgen bands without shielding would have to be limited to one hour.

While the *Explorer* satellites (I, III and IV) discovered and measured the first radiation belt during their powered lifetimes, it was the instruments in *Pioneer III* that discovered the second radiation belt and measured accurately the varying intensity levels of each. The apogee of the *Explorer* satellites did not extend even to the center of the first band at 2,400 miles.

Pioneer III apparatus consisted basically of two small Geiger counters. The counters, one 2½ inches long and the other 1½ inches long were designed to measure intensity levels without distinguishing among the types of particles. The radiation instruments and the probe's radio transmitter provided continuous data for almost all of the 36-hour flight.

The larger Geiger counter was set to transmit intensity counting rates geared to three scaling factors—512, 8192 and 131,072 counts per second. The smaller was set to operate with less sensitivity on a different circuit in order to give a continuous check on the performance of the larger counter. The counters were manufactured by Anton Electronics Laboratories of Brooklyn. This firm also built the ionization chamber carried in the earlier Air Force lunar probe.

Although the *Pioneer* payload penetrated the two belts in the thickest portions above the equator, it did not intersect the bands in the polar latitudes. For this reason a cross sectional profile of the belts has been postulated assuming entrapment of the particles in the lines of force of the earth's magnetic field.

• **Map needed**—Dr. Van Allen proposed a global map of the two belts. This map can be obtained, he said, by orbiting radiation instruments in a highly elliptical polar orbit. The orbit of the radiation mapping satellite would have a perigee of 300 miles and an apogee of approximately 10 earth radii or 40,000 miles. After about one year of orbiting the earth the exact latitude limits of the bands and their cross sectional profiles would be known.

Van Allen's university team has written several proposals to NASA in past months emphasizing the necessity for the polar orbiting radiation satellite. The payload would consist of about 100 pounds of instruments comprised largely of radio batteries.

Astronautics Tests

Dec. 23—*Atlas* launched for a perfect 4000-mile flight from Cape Canaveral. Efforts to recover the nose cone (no passenger) were unsuccessful. This was the 17th firing, and was test of guidance.

Dec. 24—*Bomarc* fired against a jet interceptor drone. Results of the test were not announced.

Dec. 23-24—*Titan* airlifted from Martin-Denver to replace the one that failed to lift off the pad on Dec. 20.

Dec. 30—*Polaris* fired from Canaveral. Destroyed after about 1½ minutes of flight. This 22nd test was first for both stages.

The payload could possibly be drastically reduced by substituting solar batteries instead of the planned mercury batteries.

After authorization from NASA—and the agency is interested—Van Allen said he would need from six to eight months to prepare the satellite. Booster vehicle for this "heavy" high-orbiting payload would probably be similar to the *Thor* configurations planned for the *Discoverer* program.

Dr. Hugh L. Dryden, NASA deputy administrator, who served, as the AAS Space Flight Award presentation speaker during the Society's honors night dinner, said that many radiation experiments have been planned for this year.

Opposition Developing to President's Council

WASHINGTON—Strong opposition is developing on Capitol Hill against President Eisenhower's apparent attempt to avoid the establishment of a Cabinet-level science agency by setting up a new Federal Council of Science and Technology.

The President, on the advice of his Science Advisory Committee, recently approved the establishment of the new science council, which has no power, but will advise the President and government agencies on science matters. Many observers saw the President's action as a move to head off the creation of a science agency introduced and supported by Democrats during the last session of Congress.

Sen. Hubert H. Humphrey (D. Minn.) who was the author of a science agency bill during the last session, told m/r that he plans to introduce another bill which would integrate basic government science agencies such as the Atomic Energy Commission, the National Aeronautics and Space Administration, the National Bureau of Standards and the National Science Foundation under one department. Humphrey, chairman of the Senate Government Operations Committee's Reorganization Subcommittee, said he will hold early hearings on the bill.

Other Senators who may be expected to push for a new science agency are John L. McClellan (D. Ark.) and Ralph W. Yarborough (D. Tex.), co-sponsors of the Humphrey bill during the last session; and Sen. Estes Kefauver (D. Tenn.), who introduced a similar measure.

The fate of science agency legislation, of course, rests in the hands of Senate Majority Leader Lyndon Johnson (D. Tex.) and House Speaker Sam Rayburn (D. Tex.) who have not made their views publicly known.

The President's Science Advisory Committee also recommended that its chairman, Presidential Science Advisor Dr. James R. Killian Jr., be made head of the new council.

Although the Advisory Committee's report opposed the establishment of a science agency, the science council seems to be a step in that direction. Killian now attends meetings of the Cabinet and Security Council, and the groups to be represented on the Council would be those represented in a science agency.

Government scientists generally approved of the President's action. Dr. Hugh L. Dryden, Deputy Director of NASA, said he was opposed to the idea of setting up a separate science department. U.S. IGY Chairman Dr. Joseph Kaplan said he did not believe such an agency would solve the problem.

Big Pine Telescope To Go in Operation Soon

WASHINGTON—Distant stars such as the globular cluster on this week's cover will be only a "stones throw away" when a new radio telescope observatory begins operations on the West Coast early this year.

The new observatory built by the Navy and the California Institute of Technology, is expected to have a reception range 15 times greater than any present observatories.

Constructed at a cost of $1.5 million at Big Pine, in Owens Valley 250 miles north of Los Angeles, the observatory will utilize two 90-foot diameter antennas. Early in the Spring the antennas—working in unison—will reach beyond mapped boundaries of the universe—to stars that transmitted their light and radio signals eons ago.

Light travels approximately 6 trillion miles in one year—which means that astronomers will now be able to map our universe out to about 180 million trillion miles.

Congress Will Keep Eye on Space Program

New space committees being formed in both houses; legislation likely to come in fields of patent rights, procurement, tax application and military procurement practices; industry ready to battle for new renegotiation act.

By Erica Cromley

WASHINGTON—Formation of two new Congressional Space Committees, to join the already missile-conscious Armed Service and Appropriations Committees in a Democratic Congress, make it seem almost certain that the Eisenhower Administration's missile and space program will come up for legislative overhauling during this session.

After Congress convenes Jan. 7, the Mahan House Defense Appropriations Subcommittee probably will ask some searching questions on reliability studies and quality control of missile and other programs—questions directed at all services.

More quizzing will come at the budget hearings, especially if the administration follows its apparent plan to limit the country's space spending to less than a billion dollars. Overall budgets of both ARPA and NASA are set at about $500 million each, only part of which can be used for space. Under present ground rules the services won't budget for space projects per se.

As for new legislation, the following measures will have top priority in the defense and missile field:

Patent rights.

Procurement changes.

The Renegotiation Act.

Indemnification against missile accidents.

Pre-merger notification of major companies.

More uniform tax application.

No new "spectacular" legislation equal to last year's establishment of the National Aeronautics and Space Administration is expected, although there has been some Congressional interest in creation of a Department of Science.

The Administration is expected to submit a budget of about $40.5 billion. If Congress increases it, it probably will add funds for missiles, electronics and military space vehicle development.

• **Patent rights**—Although Congress is usually reluctant to amend legislation before it has had time to prove itself, agitation over patent restrictions written into the National Aeronautics and Space Administration Act may push legislators into early action. Under NASA contracts, patent rights may be taken by the space agency. Industry would like its space agency contracts to read like those of the Defense Department which grant commercial patent title while maintaining royalty-free use for the government.

Although the act provides for patent rights waivers, the big hurdle will be NASA's Inventions and Contributions Board which will have to rule on each case individually. There is no industry representation on the five-man board.

Said an Aircraft Industries Association spokesman: "It's going to be a mighty slim crop that survives the board. Board members are going to do a lot of soul searching before they waive the government's rights on an invention."

The patent provisions as they now stand, industry contends, will put a damper on incentive for new developments and, therefore, in the long run it is in the government's best interest to grant commercial rights.

• **Groups involved**—Organizations working on recommendations to ease the patent restrictions include the National Association of Manufacturers, the Aircraft Industries Association, National Security Industrial Association, Electronic Industries Association, and the American Patent Law Association.

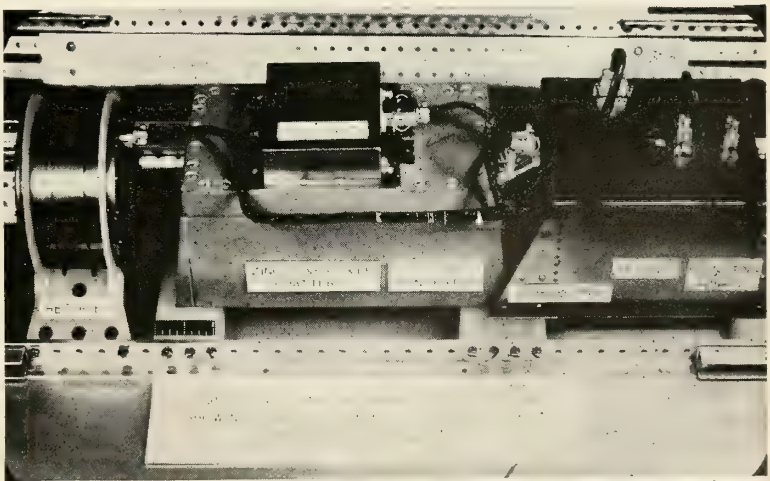
Members of the NAM's astronautics subcommittee met recently with representatives of the space agency and the Patent Office to state their case, and received a sympathetic hearing. According to an NAM spokesman, NASA has already issued instructions that patent restriction clauses will be written only into contracts involving research and development.

NASA is also drafting a regulation to exempt non-R&D contracts from the patent provisions of the act. Industry feels, however, that while this is a concession, very few patents are likely to develop out of supply contracts.

Industry also objects to the "patents oath" clause of the provisions requiring patent applications involving air or space-utility items to be accompanied by a statement "executed under oath" that these did not grow out of any space contract. "This," said Elmer Gorn, Assistant General Counsel for patent matters at Raytheon, "is a slap in the face at industry."

The provision gives the Commissioner of Patents broad power to demand the oath of any application "which appears" to him "to have sig-

Atlas Satellite's Payload



COMMUNICATIONS RELAY installed in *Atlas* missile now circling Earth was developed by Army Signal Corps in coordination with RCA and other firms. Total weight of equipment shown in cross section is about 150 pounds.

nificant utility in the conduct of aeronautical and space activities." NASA is reported to be compiling a list of items for the commissioner's guidance.

Although the intent will be to keep this within reasonable bounds, industry feels that as the agency's field of interest grows, the list will likewise expand. Repeal of this policing power will have high priority when time is ripe for NASA act amendments.

- **Procurement**—A bill calling for major military procurement changes involving weapon system management and procurement will be re-introduced by Sen. Leverett Saltonstall (R-Mass.). Although the bill will be modified somewhat from that introduced in the last session, the main provisions are expected to remain. These include extension of the management system to all major weapons programs and would put responsibility for development of weapon under one head.

Included in the bill's provisions is a requirement that major prime contractors extend full subcontract opportunities to small business to increase its participation in subcontracting.

Another section of the bill provides exemption of incentive fixed-price contracts from renegotiation, but this is expected to end up as separate legislation.

It is expected that many provisions of this measure will be permissive rather than mandatory.

Details of the bill are now being worked out with Pentagon officials.

- **Renegotiation**—Industrial associations like the AIA have been working diligently on renegotiation proposals for presentation to the new Congress.

Industry feels that if substantial savings are made under incentive contracts, future incentive is lost if these are to be taken away in renegotiation proceedings. It is proposed that the Renegotiation Board be required to carry the burden of proof in establishing that cost savings did not result from the efficiency of the contractor if profit does not exceed 10%.

- **Appropriations**—It is considered highly unlikely that Congress will tamper with the defense budget figure except to up it. Of the reported $40.5 billion plus (more likely $41 plus; see m/r December 22, p. 15), missiles and space equipment will take at least $6.8 billion. Missile production spending for Fiscal 1960 is expected to go up at least one billion over 1959 to $4.4 billion, with Research and Development to rise "slightly" over this year's $2.4 billion.

While missile spending has climbed annually, aircraft production money will drop under $7 billion for the first time in eight years.

- **Indemnification**—Missile industries would like up to $500 million indemnification in case of major rocket accidents because private insurance companies will not provide full coverage. Favorable Congressional action this year is a good possibility.

- **Taxes**—Congressional observers see little possibility of a reduction in the present 52% corporation tax rate which must be considered before June. Likely instead is a more uniform application of the tax base with a lifting of special deductions and an increase on certain "specially favored income."

York Sees No Conflict Between ARPA and R&E

WASHINGTON—The Christmas Eve-appointed Dr. Herbert York told his first press conference that as the first Department of Defense Director of Research and Engineering he would:

1. Absorb the present office of the Director of Ballistic Missiles.
2. Act under his authority to supervise ARPA and to allocate projects in the R&E field.
3. Direct all R&E projects which the Secretary of Defense thought should have such central direction. (ARPA now controls the centralized direction of all military space projects.)
4. Supervise all research and engineering projects within the Department of Defense.

Although there are many areas in which the authority of the Director of Research and Engineering and the Director of the Advanced Research Projects Agency overlap, Dr. York said he saw no direct conflict between the two. Roy Johnson, ARPA, director, would, he said, continue to report directly to the Secretary of Defense as he, Dr. York does. He did not know whether or not William Holaday, missile boss, would continue with DOD. He suggested that reporters ask Holaday.

York repeated the recent remark of Deputy Defense Secretary Donald Quarles that ARPA is a "permanent" agency. ARPA would continue, he said, to take on specific military space jobs while the R&E office would supervise all R&E projects. There would have to be, he thought, very close cooperation between his office and Johnson's. Dr. York's new salary is $22,500 annually, a reported drop from his former pay under IDA. Johnson's annual salary is $19,000.

The Director of Research and Engineering replaces the old post of Assistant Secretary for Research and Engineering, most recently held by Paul D. Foote but vacant for some time. Dr. York announced that John B. Macauley, deputy assistant secretary, would stay on as deputy and that he expected to reorganize and utilize the present staff of about 200.

In addition he will absorb the present staff of Missile Director Holaday. Holaday, has been appointed chairman of NASA's Military Liaison Committee, a salaried position.

This absorption would come slowly, York said, in order not to interfere with the projects which Holaday's office already has underway. He expected the same deliberateness in the clarification of his working relationship with ARPA. Before his new appointment Dr. York was chief scientist of ARPA.

Dr. York's new agency, like ARPA, has the authority to contract with private firms' scientific organizations and other government agencies. Dr. York said he was somewhat familiar with the DOD budget for research and development and was prepared to go before Congress and defend it.

While he would supervise the service R&D projects, his office had no intention of taking over their budgets or separate authority, he said. He felt that among his main duties was to expedite all DOD research and to see that no areas were left out of the DOD program.

As an aside, Dr. York said he felt U.S. missile and space progress compared favorably to that of the Russians. The U.S. has lagged in the satellite and high propulsion fields, he said, but is now rapidly catching up.

The R&E position is known to have been refused by several prospects previously (perhaps by Dr. York himself). Queried as to why he had accepted, Dr. York said that he had seen no reason why he could and should not do the job.

"It was as simple as that," he said.

letters

Missile Fare

To the Editor:

Thought you might be interested in the agenda we whipped up for the Martin-Cocoa Management Club meeting.

Liquid fueling cut-off (bar closed); Start solid fueling (dinner); Man all stations (open meeting); Airborne guidance (invocation); Visitor control (introduction of guests); Identification of facilities (introduction of organizing committee); Prelaunch briefing (purpose of meeting); Data analysis—prior to launch (minutes).

Crew status report (membership report); Operating procedures briefing (constitution); Program identification (introduction of speaker); Ground guidance (main speaker); Hold for special briefing (award presentation); Selection of T.C. and crew (election of officers); Deactivate facilities activation (dissolve organization committee); Switch to automatic sequencing (adjourn); Blast off (the joint is closed).

Wade Epperson, Secretary

(Ed. Note: Watch for fuel spillage)

We Stand Corrected

To the Editor:

I am referring to an article in your November 10 issue, entitled: "Cincinnati: Job Shop for Missile Industry." My main concern with the article is that it does not mention the Lodge & Shipley Company as contributing to the missile industry. Actually, Lodge & Shipley has contributed greatly both to the development of its Floturn process and Floturn machines, as well as in special lathes.

In this article there was a reference to the Cincinnati Testing and Research Laboratory and its Floturn process. The Cincinnati Testing and Research Laboratory has no connection with the Floturn process and had nothing to do with the production of the *Explorer* nose cone. The photograph of the nose cone in your article had a caption to the effect that the nose cone is a product of the Cincinnati Research Laboratory which, of course, is not true. Actually, the picture was taken in the Lodge & Shipley, Floturn Department, and it shows Mr. Dolle, President of Lodge & Shipley Company, holding an *Explorer* nose cone.

Arthur V. Baumann
Sales Promotion Manager
The Lodge & Shipley Company

Editors Note: We regret the error and the oversight in not mentioning the fine work of the Lodge & Shipley Co.

west coast industry

by Fred S. Hunter

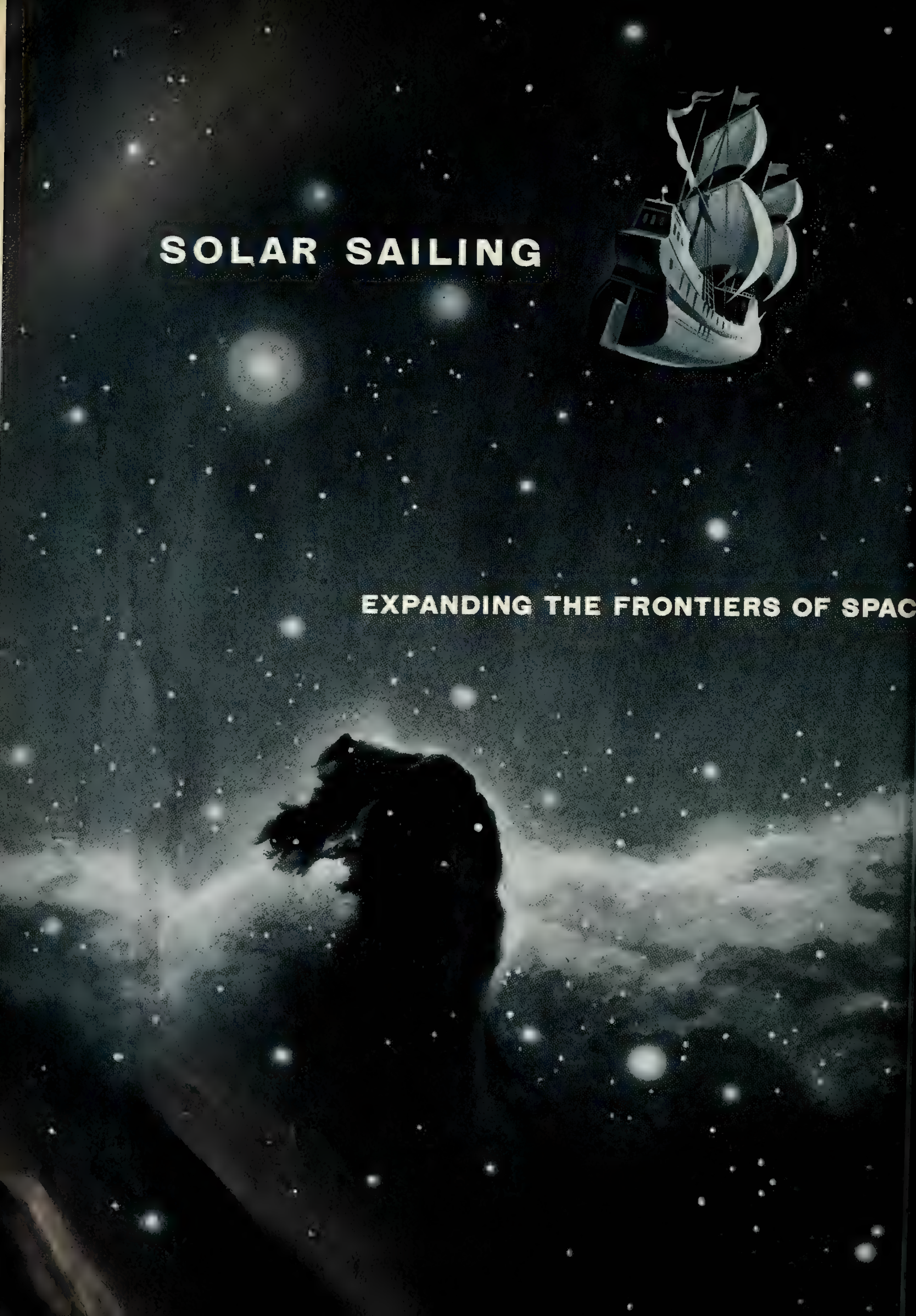
Lockheed's Missile Systems Division is making sure that it doesn't get fenced in as the California division did at Burbank. This is the reason for its recent land acquisitions at Sunnyvale, 16½ acres in one parcel, 154 in another, to add to the original 275-acre site. A building for a project is planned for the smaller parcel. There is nothing specific in mind for the 154 acres. This is insurance for the future. Lockheed's MSD also has an option on an additional 200 acres lying between the Sunnyvale plant and the Navy's Moffett Field for the same reason.

You need room when you expand in this business and you may need it fast. Four years ago—before Sunnyvale—Lockheed's MSD accounted for 1% of Lockheed's total business. Today it is 33%. In that same period of time the payroll has grown from less than 1000 to more than 14,000 and, increasing at the rate of 200 per week, will hit 15,000 by the end of the year. It is now the San Francisco Bay area's biggest employer. But it also has employes at 13 other locations, including the military test bases, such as Canaveral, White Sands and Vandenberg; tracking stations in Hawaii and Alaska; the engineering laboratory at Palo Alto; the testing site in the Santa Cruz Mountains, and personnel recruiting offices in Chicago and New York.

It is interesting to note that despite the big planning program at Sunnyvale, Lockheed has no intention of letting go of the sizeable facilities it leases from the City of Los Angeles at the Van Nuys Airport. This is the site of the *X-7* test vehicle and *Q-5* drone projects. MSD has moved a design group back into Van Nuys and is making some proposals from there. Lockheed's third quarter report, for example, makes guarded mention of a new ballistic concept (probably a version of WS-199B m/r, Dec. 1, p. 11) that has been proposed from the Van Nuys facility. The payroll at Van Nuys currently totals about 3300. It may dip a little, but it is being forecast to run within the 3000-3500 range in 1959.

A further increase of at least 50% in the specific impulse of chemical systems is attainable over the operational liquid rocket systems of today, Dr. Robert Thompson, Rocketdyne research manager, declares . . . Cohu Electronics booked its largest single TV sale to date in a $300,000 order from Douglas Aircraft Co. for a closed-circuit system to be used in observing rocket-engine tests at Vandenberg Air Force Base . . . Hoffman Electronics regards its accomplishment in mass production of high-efficiency solar cells as significant because of past hesitancy on the part of many research programs to use solar power due to uncertainty of production capability . . .

"Never forget that it is the powerplants that make the range and payload possible," Maj. Gen. Ben I. Funk, commander of the Air Materiel Command's Ballistic Missile Center, told a meeting of supervisors and department heads on the *Titan* project at Aerojet-General Corp. Gen. Funk disclosed that Aerojet contracts with the Air Force now total $252 million. The company has nearly 5000 persons employed on development, production and testing of the *Titan's* rocket engine at its liquid-rocket plant at Sacramento.



SOLAR SAILING

EXPANDING THE FRONTIERS OF SPAC

SOLAR SAILING: Space travel with the aid of solar radiation pressure—an area of advanced research at Lockheed. Vehicle would employ a sail that would be raised and lowered in flight. The artist has depicted Magellan's ship "Trinidad" to symbolize man's great voyages of discovery.

CHNOLOGY

Lockheed Missile Systems Division is engaged in all fields of missile and space technology—from concept to operation. Advanced research and development programs include—man in space; space communications; electronics; ionic propulsion; nuclear and solar propulsion; magnetohydrodynamics; computer development; oceanography; flight sciences; materials and processes; human engineering; electromagnetic wave propagation and radiation; and operations research and analysis.

The successful completion of programs such as these not only encompasses the sum of man's knowledge in many fields, but requires a bold and imaginative approach in areas where only theory now exists.

The Missile Systems Division programs reach far into the future. It is a rewarding future which men of outstanding talent and inquiring mind are invited to share. Write: Research and Development Staff, Dept. A-29, 962 W. El Camino Real, Sunnyvale, California, or 7701 Woodley Avenue, Van Nuys, California. For the convenience of those living in the East or Midwest, offices are maintained at Suite 745, 405 Lexington Avenue, New York 17, and at Suite 300, 840 N. Michigan Avenue, Chicago 11.

"The organization that contributed most in the past year to the advancement of the art of missiles and astronautics."

NATIONAL MISSILE INDUSTRY CONFERENCE AWARD

Lockheed / MISSILE SYSTEMS DIVISION

SUNNYVALE, PALO ALTO, VAN NUYS, SANTA CRUZ, SANTA MARIA, CALIFORNIA
CAPE CANAVERAL, FLORIDA - ALAMOGORDO, NEW MEXICO

IDA's 'Brain Factory' Guides Weapons Choices

Five universities work with Pentagon to provide staff for secret projects

by E. E. Halmos, Jr.

WASHINGTON—A remarkable partnership between five top technical universities and the highest echelon of the U.S. military is today producing results that will have far-reaching effect on the future defense of the nation.

For the past two and a half years, the universities—banded into a nonprofit corporation—have been working on projects so secret that not more than a dozen men know the complete details. But the results coming out of this "brain factory" are the guiding principles on which the Department of Defense makes its decisions on weaponry for which the nation will spend its money, and on which the nation will risk its future.

As of now—working on "cost-reimbursement" contracts—the university group has contracts totalling about $3.6 million, from two agencies of the Defense Department. Some 225 people, 130 or more of whom are top-flight scientists, are on the payrolls.

The group calls itself, somewhat whimsically, IDA—Institute for Defense Analyses. And IDA is a girl the like of which never existed before, in the U.S., or anywhere else.

• **Genesis**—IDA has five actual parents, who, in April, 1956 became a nonprofit Delaware corporation in order to fill a need that was recognized when the late Defense Secretary James Forrestal created the Weapons System Evaluation Group (WSEG) as an inter-service agency to provide the Joint Chiefs of Staff, himself and others with basic information for decisions on new weapons, or better uses for older ones.

Initial founders were the California Institute of Technology, Case Institute of Technology, Massachusetts Institute of Technology, Stanford University, and Tulane University.

Evidence of how closely associated these organizations have been with missiles and with space technology is the fact that both Dr. James R. Killian, Jr.—now scientific advisor to the President; and Dr. T. Keith Glennan—now head of the National Aeronautics and Space Administration—were at one time chairmen of IDA's board of directors.

A grant of $500,000 from the Ford Foundation put the new organization on a solid financial footing at once.

And the terms of the initial contract with DOD outlined a broad field of activity: "to provide personnel, facilities and material required for surveys of the effectiveness of various weapons systems; evaluation of new equipment in the light of military requirements; evaluation and analyses of military problems to predict the operational behavior of new materials and equipment.

"Development of new tactical doctrines to meet changing military requirements; studies and reports on the technical aspects of strategic planning; and analysis of actual combat reports, tactical and strategic plans, and field exercises . . . with a view to determining how existing weapons . . . could be more effectively employed."

IDA Organization

The Institute for Defense Analyses has a formidable number of top scientists, educators and government leaders serving as officers or members of the board of trustees.

Maj. Gen. James McCormack, USAF (Ret.) is president, Dr. Albert G. Hill is vice-president and director of research. Paul V. Cusick is secretary-treasurer.

General McCormack, now with Massachusetts Institute of Technology, is chairman of the board of trustees. Other members are:

William A. M. Burden, public trustee.

Thomas W. Ford, Stanford University.

George W. Green, California Institute of Techology.

Dr. Rufus C. Harris, Tulane University.

Dr. Harlan Hatcher, University of Michigan.

Dr. Albert G. Hill, IDA.

Dr. John A. Hrones, Case Institute of Technology.

Marx Leva, public trustee.

Dr. Joseph C. Morris, Tulane.

Dr. Philip M. Morse, M.I.T.

Thomas P. Murtagh, Case.

Dr. James A. Perskins, public trustee.

Laurance S. Rockefeller, public trustee.

Dr. H. P. Robertson, California Institute of Technology.

Dr. Frederick E. Terman, Stanford.

Dr. Eric A. Walker, Pennsylvania State University.

• **Buildup**—That charge envisioned an unusual operation—a private group to pool the brains and know-how of the civilian scientific community of a nation with those of the military. And it took some unusual management techniques to build up the necessary staff.

One significant source of staff members are the universities themselves—not only the five founding organizations, but the academic community generally.

IDA pays special attention to the means for enabling university scientists to devote some part of their time to national security problems. Many of these people, of course, are already involved in on-campus military research projects, or service on government advisory committees.

But more particularly, IDA offers flexible and personalized arrangements for the university faculty member or research worker who is in a position to take a leave of absence for a term or a year—a person who does not feel able to accept a civil service appointment, yet wants to apply his time to problems in IDA's sphere of interest.

"It keeps bringing in fresh ideas, fresh viewpoints," comments President James McCormack. "We deal in brainpower, knowledge, ability to assess and analyze. We can't afford to stagnate."

Of IDA's 225 staff members, 150 are assigned to work with WSEG and the Joint Chiefs of Staff; and 47 work on projects for the Advanced Research Projects Agency.

In addition, a permanent staff of 25 military men, representing the three services, is assigned to WSEG, and works with institute scientists.

• **Assignments**—IDA gets its assignments either from WSEG or ARPA. An assignment, for example, may call for a comparison of two weapons systems being planned—or even in experimental stages. WSEG wants to know, for instance, whether it will be practical to manufacture the two systems, or whether only one should be authorized; what will be required in the way of support activities; what the manufacturing limits will be; how much material and money will be involved; how much manpower; how soon either system could be ready for delivery of hardware; the feasibility of employing such a weapon—whether troops can handle, or specialists must be trained; what tactical uses could be made of the two—and many other matters.

IDA looks over this assignment, and agrees to handle it. (The Institute has occasionally returned such requests for further definition or other reasons). It then selects from its staff the best qualified man in the particular field, and appoints him as project officer.

And around this man, it assembles a team—assigning military men to provide necessary background and knowledge; and any specialists whose skills seem to fit into the requirement.

Now begins an intensive job of collecting all known data on the subject in hand, study of any tests, opinions and reports from any source; a search that may take investigators through libraries, military repositories, and company and laboratory records.

The information is gathered, evaluated by the project staff, put into final report form, and submitted to whichever agency has requested it. These reports have run from a folder of a few pages to mammoth documents running (with supplements) to 800 pages or more.

Some of them—under great urgency —have been produced in as little as two weeks. Most take longer, for careful study of all factors.

In any event, the results may never see the light of day, outside the most carefully guarded rooms in the Pentagon. It may be, however, that in some future year, some of the information may be made available to the interested public.

• **Results**—Because of the extremely sensitive nature of the work, it is difficult to report the exact nature of what IDA does.

However, in its second annual report, IDA pointed to its participation in the famous Gaither report, made public (in part) last year. IDA got into that picture in June, 1957, with a request from the National Security Council to support a special study group under the chairmanship of H. Rowan Gaither. This group was set up to explore the conditions and capabilities of the U.S. "Heartland" defense system, in the event of an all-out enemy attack.

Among the considerations were: U.S. retaliatory capacity, bearing in mind the fact that U.S. actions in continental defense would affect the actions and attitudes of its principal military allies and other nations with whom the United States has mutual commitments. Also to be considered was the fact that all branches of the U.S. government that would figure in national security are competitors for budgetary support.

Specifically, IDA was asked to recommend and assist in gathering the membership of the panel; insure the quality and technical support; assist in research, fact finding, synthesis and conclusion; and provide all necessary management and supporting service.

Other problems on which the organization has worked, or is working, include:

1) Studies of Air Defense: of the U.S. heartland; of special areas of particular interest overseas; of territories of allies; of U.S. ability to operate from overseas bases; of U.S. ability to launch retaliatory forces.

2) Studies of potentialities and hazards of atomic weapons: if used by the U.S. or against the U.S.; possible effects of radioactive fallout on enemies, on friendly nations, on the U.S. and its forces; relationships between nuclear capabilities and force structures, the logistical problems attendant on force deployment and mobility.

3) Studies of wars of less than all-out intensity: of the relationship between capability of all-out war and the conduct of lesser wars and diplomatic maneuver in the absence of active war —of achieving national objectives without resorting to war.

4) A study, with the North American Air Defense Command, to explore certain problems of defense against types of offensive attacks considered possible in specified time periods of the future.

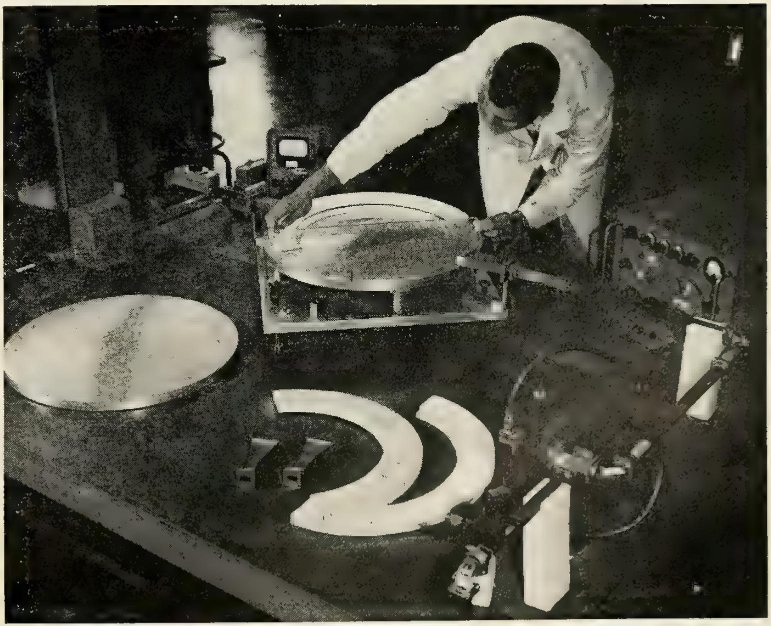
5) Service as a technical monitor for the Department of Defense in field tests of especially important new military systems.

• **Why it works**—IDA was formed after three separate government commissions (beginning with the Hoover commission which had recommended such a contract operation.) Its contracts and methods have been carefully scrutinized—and there has even been some Congressional criticism, mostly on the ground of high pay to scientists, and too great civilian participation in military matters.

However, no one has argued that the system doesn't work—and work well.

One reason is obvious. IDA can put its people to work without any service-connected prejudgments, is not in the position of having to defend any particular point of view. And it can call on the very best scientific brains in the United States to help solve its problems.

Protection for Radar Antennas



RADOMES THAT provide radar antennas with protection against the elements must be highly transparent to radar waves. Here, a Stanford Research Institute engineer determines electrical characteristics of new high-strength radome walls. The equipment shown permits the use of a narrow strip of the radome to simulate a large, flat radome panel.

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propulsion engineering

by Alfred J. Zaehringer

Neutrons and ions for rocket propulsion are being researched at the University of Heidelberg. A fission reactor using beta particles given off by cesium-137 is used. The particles are sent through two hyperbolic quadropole magnets. Beta particle jets of about 40 mm long have been produced.

Photon propulsion systems may evolve from present plasma jet work. This seems to be implied by Dr. Eugen Saenger who extrapolates present work to the point where temperatures will reach 400,000°K with high plasma pressures. Photon rockets would make possible flight speeds of about a million kilometers per hour.

Critical mass for U-238, U-235, or Pu-239 is several inches in diameter and weighs 35-65 pounds. This was given in an older Russian report surveying nuclear propulsion for rockets, ramjets, and turbojets. Thus, atomic fuel costs for an airborne reactor system would be $250-500 million at present U-235 costs.

Propellant systems favored by the Soviets are: oxygen and ozone for oxidizers, and the light metals and metallo-organics for fuels. Hydrogen figures big in high performance upper stages and for nuclear rockets. Apparently fluorine does not have high favor because of handling difficulties.

Shaped-charge atomic explosions may figure in rocket propulsion systems being investigated by Los Alamos Scientific Laboratory. Current feeling is that each directed atomic explosion (say a fraction of a kiloton) would give several times more thrust per propellant weight than the reactor-working fluid system such as being tested on *Rover* rocket.

Atomic oxygen may drive the Air Force *Hare* missile. Catalytic surfaces within the missile would allow the free oxygen atoms to recombine to form molecular oxygen. Energy available from such a reaction is 10^{-6} calories per cc of air at an altitude of 100 km. Proposed speed of *Hare* on oxygen drive would be about 1330 feet per second.

New fuel-binder possibilities are pouring out of the chemical industry. Minnesota Mining & Manufacturing (recently awarded an ARPA solid propellant contract) has introduced an epoxy extender and plasticizer for solid propellant use. American Petrochemical has a new flexible polyester on the market which may improve present brittle binders. Atlas Powder came out with a polyether urethane while DuPont uses PMDA and an epoxidized plasticizer to produce a rigid vinyl from castable plastisols. Finally, Monsanto introduced Mod-Epox, a cost/viscosity modifier for epoxy resins.

Handling and shipping practices have been outlined for HiCal-3 by Callery Chemical, indicating production status. Shipment will be made in one ton chlorine cylinders (190 gal) and LPG cylinder (53 gal). ICC classification is Class B Poison with permissible shipment by rail freight or truck. While the company is making available samples of diborane, the solid decaborane may be available in 1959. Amine boranes and trialkyl boranes are being produced now.

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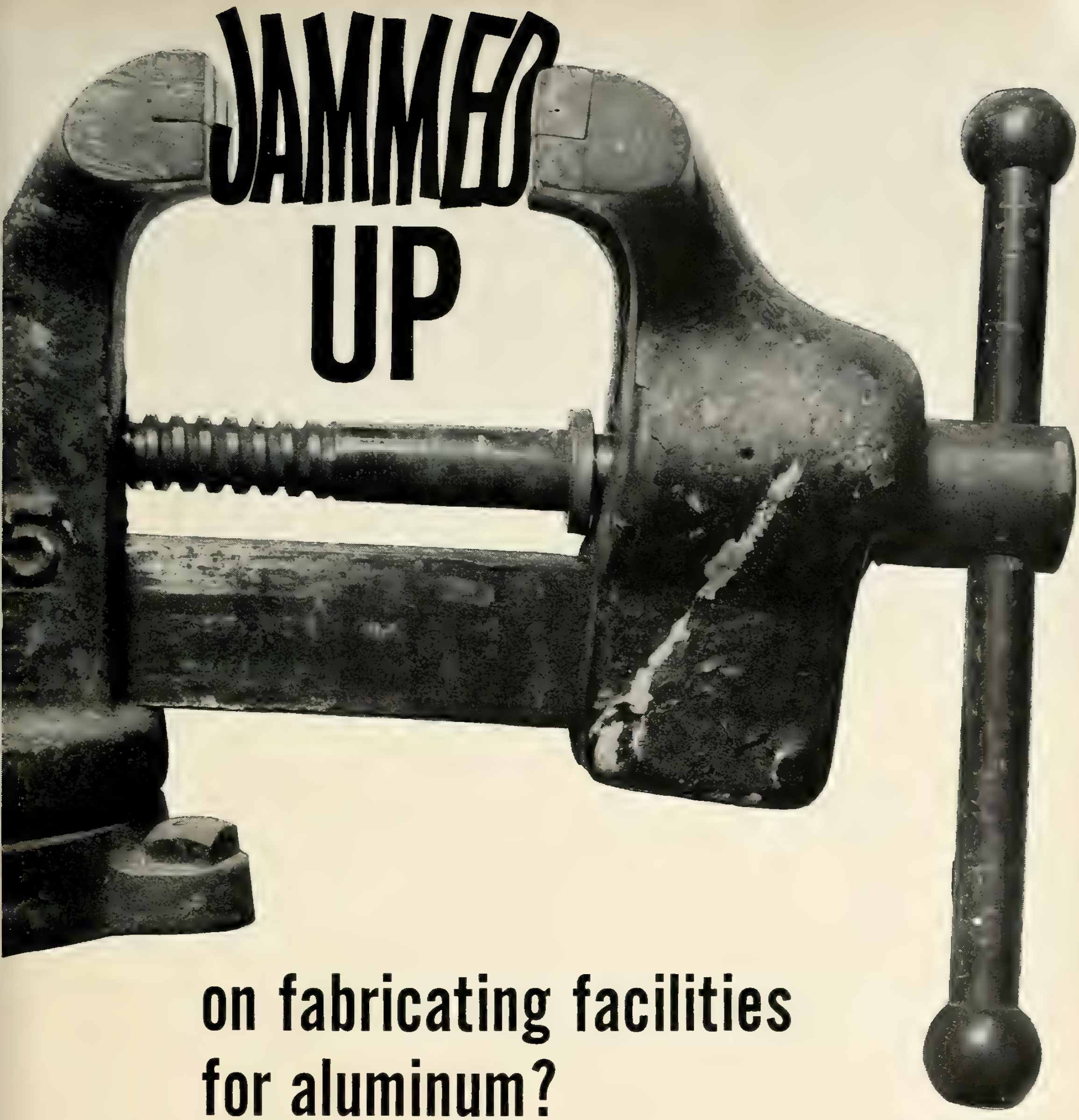

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Lear Designs Guidance For Manned Satellite

Broad features appear feasible in system for integrating accelerometers and retrofitting 'Bootstrap' gyros

Los Angeles—Design of an inertial guidance system for use in a manned orbital cislunar satellite is underway at Lear Astronics, a division of Lear, Inc., Santa Monica, Calif.

Broad system features have been proven feasible and a technological evaluation has been made. Synthesis of system elements and total system performance appraisals are not yet complete.

Astronics has not revealed hardware details, but its gyro and platform technique reportedly involves advanced and unorthodox gimbal configurations.

Designed for integrating accelerometers, the system is adaptable also to possible retrofit of Astronics' "bootstrap" gyros—a concept still under study.

• **Reduce drift rate**—The bootstrap term describes gyros equipped with a means of detecting drift rate rather than total drift. Once drift rate has been established, it can be zeroed out of the system. The technique may prove capable of reducing drift rates in existing gyros by factors as high as 10 to 100. Applicable to ordinary gyros, the concept can reduce component costs relative to accuracy demands. Rotating bearing, flotation and other ultra-precise requirements can be eliminated. Tests indicate a probable value of less than 0.01° per hour average free drift can be achieved.

The inertial system incorporates vertical reference data; allowances for flight profile pertrubations; a platform-computer configuration with integrity of solution in any order of powered vs. free-fall flight; and platform configuration which maintains verticality without gyro precessing in the high rates of angular progression around an orbit.

Other provisions include elimination of possible adverse effects on gyro accuracy with thrust application following a zero acceleration period, and possible mixed system performance with star tracking and ground link data inputs.

Trajectory information incorporates position in three coordinates and the three components of velocity. Prediction and correction of trajectory is accomplished by computer/platform configuration which predicts the point where penetration is to be initiated based on existing initial conditions and no rocket power. The information is used also for correction data specifying thrust requirements for intercept of desired space point.

Monopropellant or dry gas rockets would be used for attitude control. Silvercell batteries would supply basic DC power. Conversion to AC is planned by use of Lear-developed, lightweight plasmotors.

The plasmotor consists of a tube containing an ionized gas which conducts an electrical current at intervals determined by the irradiation rate provided by a nuclear source. When the gas ionization reaches saturation, a pulse is released. Said to maintain highly accurate AC frequencies, a several hundred watt unit is about the size of a standard receiving tube.

Final system configuration would be tied closely to space cockpit design program of the company's Grand Rapids Division. The studies stress information presentation and amount of data actually required by a crew.

• **Another project**—The year-old Astronics division is working also on an Air Force-funded project for a learning rate integrating gyro-autopilot —an outgrowth of previous MIT auto-

Ford Instrument Cited

AN AWARD for outstanding service to the Army Ordnance Missile Command and the Army Ballistic Missile Agency was presented recently to Ford Instrument Company, a division of Sperry Rand Corp. Col. Calvin Heath of ABMA's Industrial Division makes the presentation to Charles S. Rockwell, president of Ford Instrument. On left is L. S. Brown, manager of Ford's Missile Division on right is Harry Vickers, president of Sperry Rand Corporation.

FIREBEE...THE HIT OF PROJECT WILLIAM TELL

"I'LL NEVER WANT TO FIRE AT TOWED TARGETS AGAIN!" That's the typical reaction of Air Force interceptor pilots after they fired at Ryan Firebee jet targets during the recent "Project William Tell" Weapons Meet. 78 Firebees, launched off the Florida coast, brought combat realism to the 10-day meet. Acting as "enemy" jet bombers, the free-flying Firebees streaked in at over 500 mph, from 14,000 to 42,000 feet, and flew an average of 31 minutes each. Air Force pilots, crews, and weapons systems met this realistic test with the most impressive teamwork and skill ever displayed at a weapons meet.

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This experienced team now is at work on the development of large-scale cast propellant motors, the design of advanced lightweight rocket hardware, and the formulation and testing of high-energy propellants with optimum physical properties for ballistic missile applications.

Inquiries are welcomed on all phases of the solid propellant field—from preliminary design to quantity production.

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pilot development.

In essence, such a servomechanism is capable of remembering what it has done in relation to a vehicle and compares what it is doing now to a past or ideal performance.

Applied to guidance systems, the concept may make it possible to design flight controls which select their own sub-routines and are capable of sensing whether such actions are correct or not.

Missile or space exploration aspects of the device would be in unmanned probes to unknown planets such as Venus. Astronics engineers say that a probe with a learning curve and judgment comparable to human may be available in about 10 years.

Astronics has been organized to meet requirements of future advanced projects. Functioning as Lear's systems division, it utilizes the team concept to integrate capabilities of other divisions and/or other equipment companies.

Where team efforts are warranted, a systems management office and a systems planning and study organization dubbed SPARC (Systems Planning for Advance Requirements Center) has been established. Management plan includes all Lear divisions, establishing a central agency for guidance and control system activities.

But, the division is not letting time slip by. The SPARC group has been operating for some time in predictions of future guidance and control system requirements. Subsystem needs have been studied as to what can or cannot be produced by Lear divisions, and Astronics has made a number of proposals jointly with organizations outside the corporate family.

Two New Reports Issued on Electronics

WASHINGTON—The Office of Technical Service, U.S. Department of Commerce has released a USAF report on a new way to protect electronic equipment against shock and vibration and a Navy report on the change in resistivity of high polymers during isothermal polymerization.

The Air Force report, titled "New medium for the protection of electronic equipment against shock and vibration," is PB 151005 and costs $2.75 from OTS. It describes the medium as a multi-layer grid of 3/32-inch Teflon rods embedded in a matrix of silicone rubber. High internal damping, believed to be produced by friction of the Teflon-rubber interfaces, is the salient feature of the new medium. Maximum

This is one of a series of professionally informative messages on RCA Moorestown and the Ballistic Missile Early Warning System.

BMEWS AND THE DEVELOPMENT ENGINEER

The Ballistic Missile Early Warning System will be the keystone of defense against enemy-launched ICBM's. The development and design engineer assigned to BMEWS will determine to a great extent the future security of the Western Hemisphere, for the successful functioning of this unique radar system will depend upon his ability to translate technological concepts into effective hardware. On BMEWS the development and design engineer must project advanced theories of analog and digital computing and data handling systems, cathode-ray or electroluminescent display systems, or any of the many facets of radar into circuits and components. He must have the analytical capability and imagination to achieve the advanced performance necessary for BMEWS.

BMEWS development is currently in progress at RCA Moorestown, the weapon system manager, and also within the facilities of several other major corporations whose efforts are coordinated by RCA. Entering the BMEWS program at an early date will afford engineers the opportunity to contribute to the basic system development and, through continuing participation, to witness its evaluation into a final operating equipment.

For further information concerning career engineering opportunities on BMEWS and other defense programs at RCA Moorestown, please direct your inquiry to Mr. W. J. Henry, Box V-13A.

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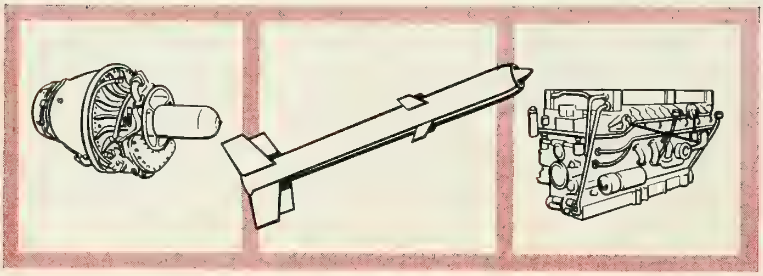

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transmissibility obtained at 0.010-inch input double amplitude was 2.1, considerably smaller than that specified in current military specs. Materials in the new medium withstood temperatures from −85 to 482 F.

"The change in electrical resistivity of some high polymers during isothermal polymerization" is the Navy report title. OTS number is PB 131582 and price is 75 cents. It describes a technique for the study of the rate of polymerization, under isothermal conditions, for typical encapsulating resins. Polymerization of epoxy, polyester and styrene resins was monitored electrically.

The plots suggest that relative rates of reaction could be conveniently obtained if a correlation between extent of polymerization and electrical resistivity were known for the particular resins studied. Results are presented for commercially available resins.

GE Scientists Describe Nuclear Power Package

DETROIT—E. Schnetzer and W. R. Corliss, scientists at the General Electric Flight Propulsion Lab, have outlined a one megawatt nuclear power package for an ion rocket.

At a recent meeting here of nuclear scientists and engineers, they reported that with cesium propellant, the 1 MW could produce 3.6 lb. of thrust at an I_{sp} of 9600 sec. Thrust to gross weight ratios of 1.8×10^{-4} were stated to be available for typical vehicles. A closed cycle system, available by 1965, would use an induction alternator.

The 1 MW power package, to be launched from a rocket or glide-type vehicle, would be about 80 feet long and have a diameter of 8 feet. A ceramic core, helium-cooled reactor produces 7.8 MW of heat. A 12-stage molybdenum turbine, consuming 4.3 lb./sec. of 2600 R helium, drives a 41-stage compressor and 400-cycle induction alternator at 24,000 RPM.

Waste heat is rejected in a packaged, three-wing, 16,800 sq. ft. radiator with an inlet temperature of 1818 R and an outlet temperature of 675 R. The specific weight of the power package is 11 lb./kw. Total weight, without shadow shielding, is 11,000 lb. Hermetically sealed parts might operate for 10,000 hours of unattended operation.

Estimated lifetime of the ceramic fuel elements represent an extrapolation of the present state of the art. Techniques for preserving the integrity of the radiator in the presence of high meteoroid fluxes remain to be developed.

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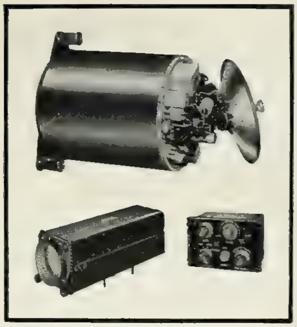

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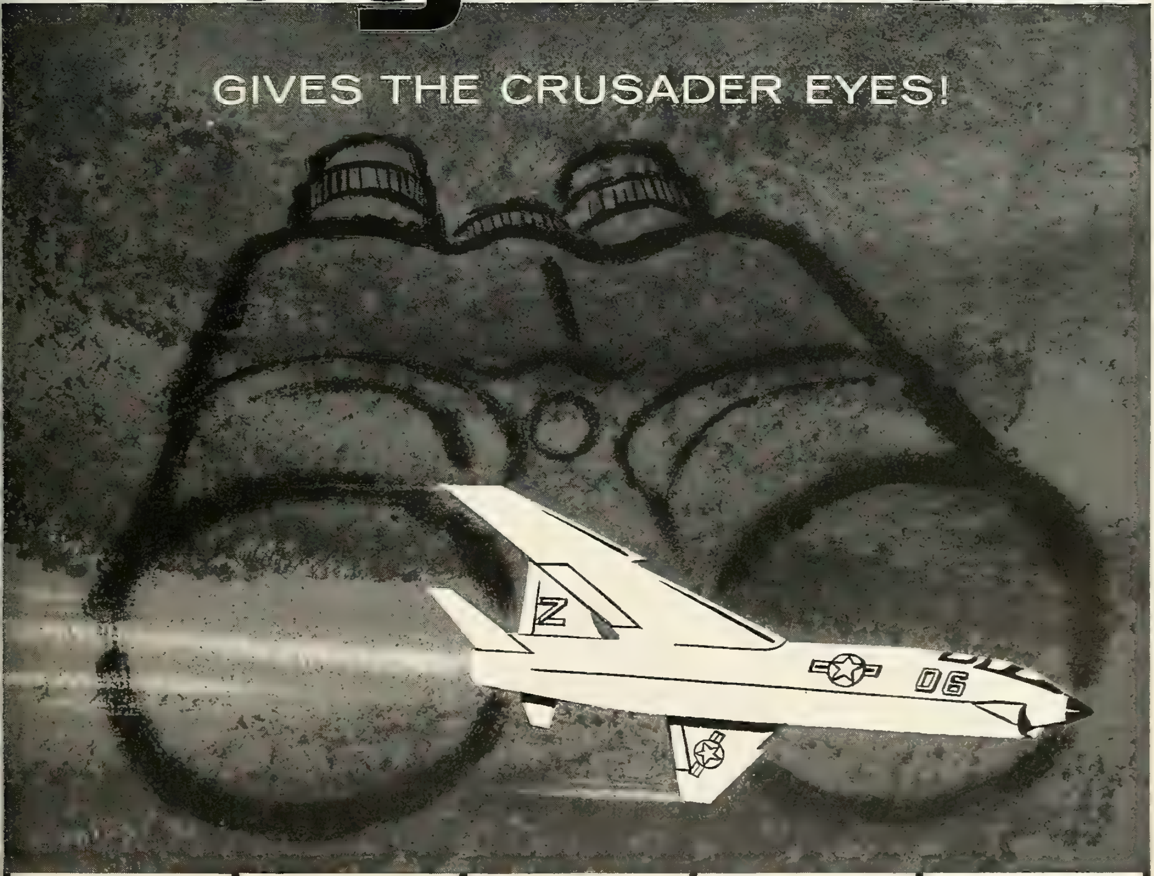

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How Lockheed helps conserve defense dollars:

The missile with 9 lives

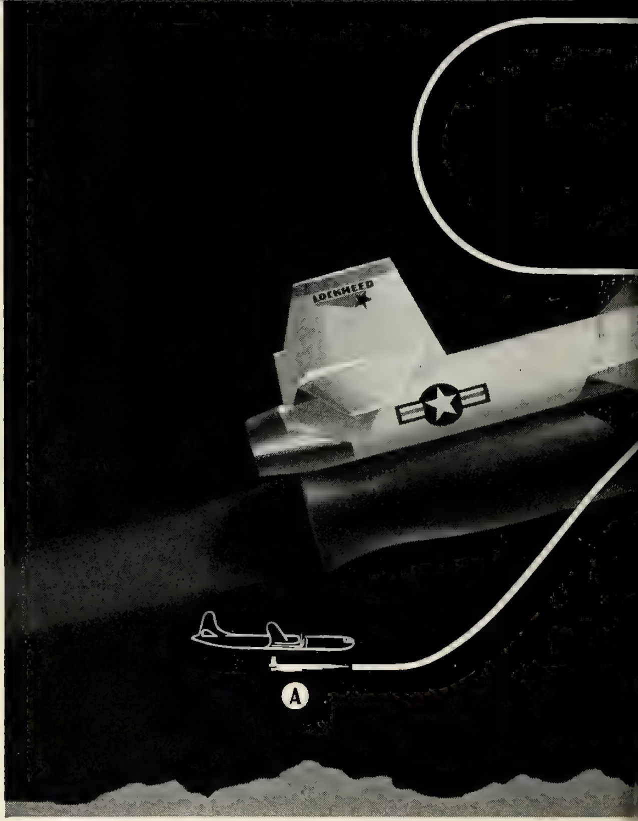
The U.S. Army's new Q-5 *Kingfisher* was designed by Lockheed's Missile Systems Division to provide our mighty arsenal of ground-to-air missiles with a realistic test of marksmanship—against high-altitude targets moving at supersonic speeds over 1500 miles-per-hour.

The *Kingfisher* is 38-feet long, 20-inches in diameter, has a 10-foot wingspan and weighs more than 7600 pounds. As it flashes across the skies it electronically simulates any desired size and type of "enemy" plane or air-breathing missile.

The *Kingfisher's* electronic Firing Error Indicator instantly and accurately tells ground controllers whether missiles fired at it are "hits" or "misses"—and automatically evaluates each missile's angle-of-attack, miss-distance, and other highly important technical data.

Undamaged by "hits" scored on its electronic image, the Q-5 *Kingfisher* is parachute recovered after each flight.

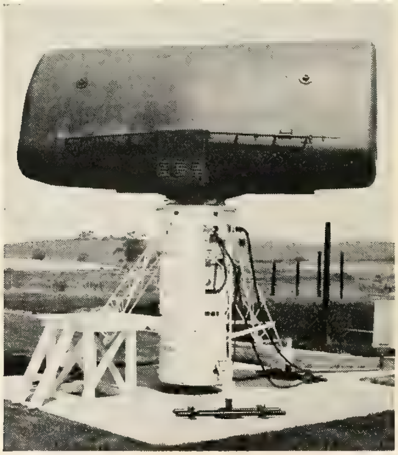
This Lockheed-developed "missile with 9 lives" will enable the U.S. Army to achieve hitherto impossible proficiency in missile marksmanship against supersonic targets—at a saving to taxpayers of approximately half a million dollars on each recovery flight.

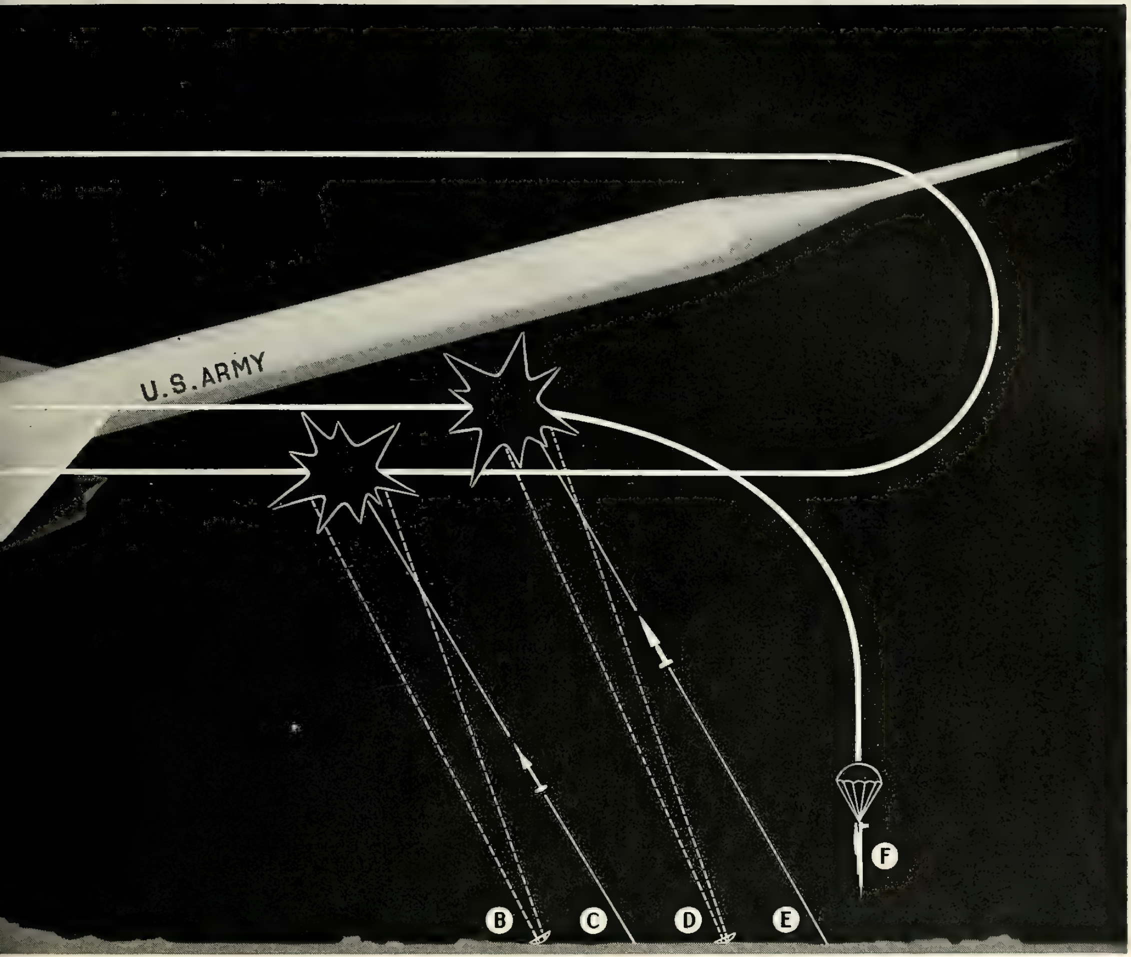


Q-5 is dropped by plane at 35,000 feet ((**A**) in diagram). Then its twin rockets ignite, propel it to speeds required to operate its ramjet engine.

Q-5 is detected as "enemy" by ground radar (**B**), and its speed, altitude, and course are fed into fire-control computer of Nike battery.

Missiles fired at Q-5 are like
used in wartime—but lack
explosive warheads. Nike missil
scores "hit" on Q-5's electronic im





Above: Entering oval flight pattern, Q-5 attains speeds over 1500 mph. Second ground radar **(D)** and missile-launching battery **(E)** practice their marksmanship until Q-5 *Kingfisher's* fuel supply is exhausted.

Left: Landing on its nose-spike in a remote, uninhabited area, after floating down by parachute **(F)**, the Q-5 is recovered by U.S. Army ground crews—to be refueled and refitted for future flights.

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JANUARY

Fifth National Symposium on Reliability and Quality Control in Electronics, Bellevue-Stratford Hotel, Philadelphia, Jan. 12-14.

Southwest Electronic Exhibit, Arizona State Fairgrounds, Phoenix, Jan. 21-23.

Institute of the Aeronautical Sciences, 27th Annual Meeting, Sheraton-Astor Hotel, New York, Honors Night Dinner, Jan. 27, Jan. 26-29.

Fifth Annual Radar Symposium (classified), Rockham Bldg., University of Michigan, Ann Arbor, Jan. 27-29.

Society of Plastics Engineers, 15th Annual Technical Conference, Hotel Commodore, New York, Jan. 27-30.

Armour Research Foundation, Fifth Annual Midwest Welding Conference, Illinois Institute of Technology, Chicago, Jan. 28-29.

FEBRUARY

14th Annual Technical and Management Conference, Reinforced Plastics Division, Society of the Plastics Industry, Inc., Edgewater Beach Hotel, Chicago, Feb. 3-5.

1959 Engineering Exposition, Balboa Park, San Diego, Feb. 26-March 1.

MARCH

IRE, AIEE and Association for Computing Machinery, 1959 Western Joint Computer Conference, Fairmont Hotel, San Francisco, March 3-5.

Institute of the Aeronautical Sciences, Flight Propulsion Meeting (classified), Hotel Carter, Cleveland, March 5-6.

Western Space Age Conference and Exhibit. For information: Domestic Trade Dept., Los Angeles Chamber of Commerce, 404 South Bixel St., Los Angeles, March 5-7.

Gas Turbine Division of the American Society of Mechanical Engineers, Turbine in Action, Cincinnati, March 8-11.

American Society for Metals, 11th Western Metal Exposition and Congress, Pan-Pacific Auditorium and Ambassador Hotel, Los Angeles, March 16-20.

The American Rocket Society, 1959 Sectional Meeting, Daytona Plaza Hotel, Daytona Beach, Fla., March 23-25.

Institute of Radio Engineers, National Convention, Coliseum and Waldorf-Astoria Hotel, New York, March 23-26.

Polytechnic Institute of Brooklyn's Ninth International Symposium, Auditorium, Engineering Societies Bldg., New York, March 31-Apr. 2.

Society of Automotive Engineers, National Aeronautic Meeting, Hotel Commodore, New York, March 31-Apr. 3.

APRIL

1959 Nuclear Congress, Municipal Auditorium, Cleveland. For information: Engineers Joint Council, 29 West 39th St., New York, Apr. 5-10.

American Welding Society, 1959 Welding Show and 40th Annual Convention, International Amphitheatre and Hotel Sherman, Chicago, Apr. 7-10.

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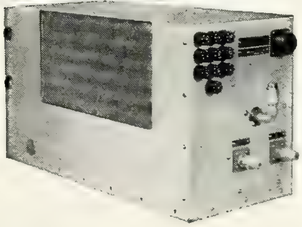

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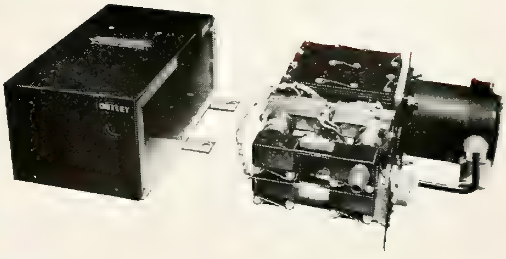

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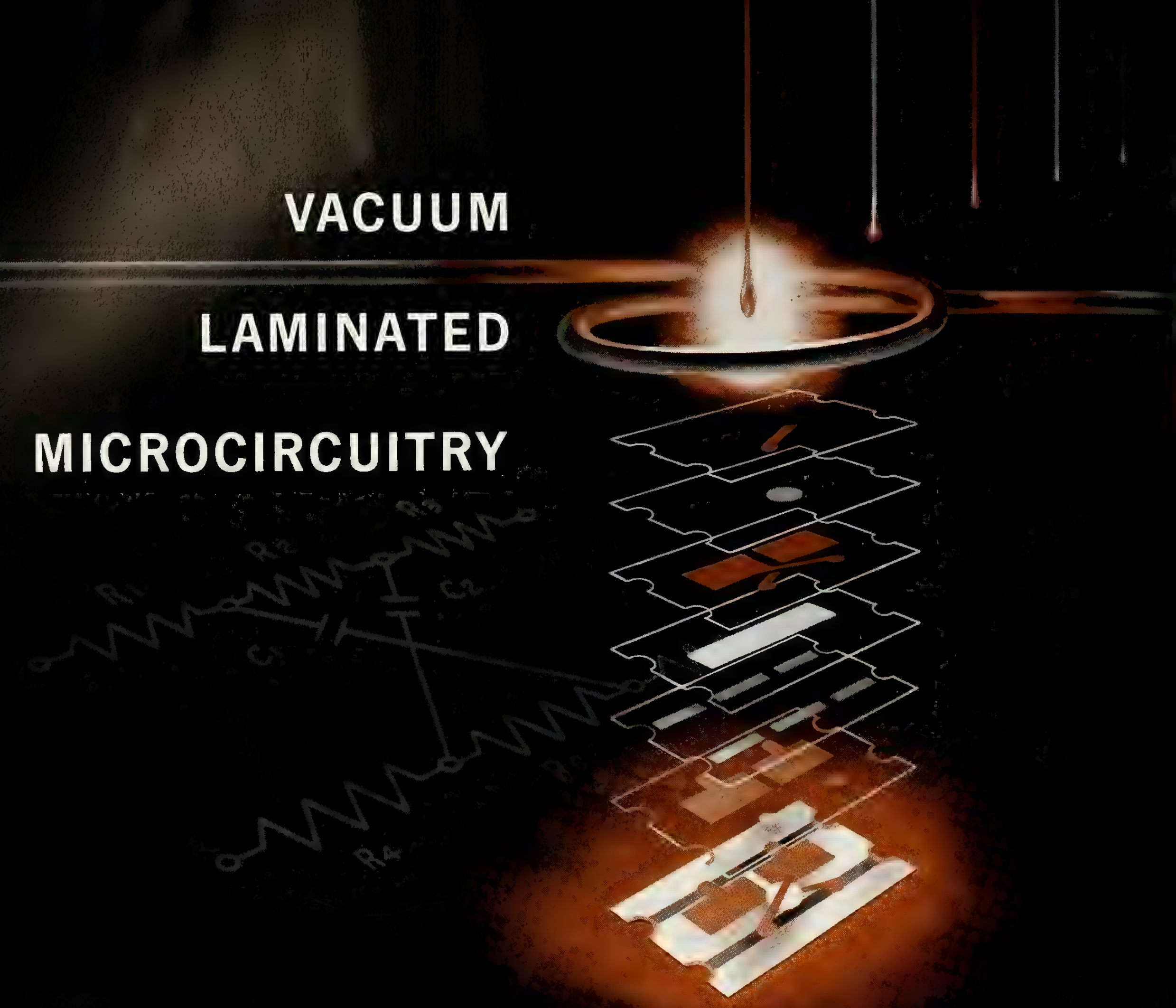

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missiles and rockets

MAGAZINE OF WORLD ASTRONAUTICS

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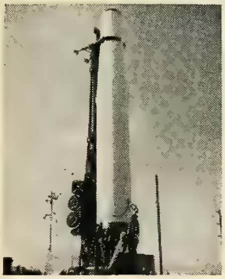
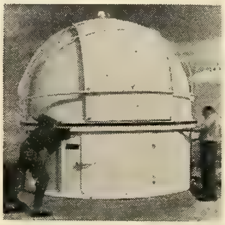
NEW FLOTATION gyro liquid undergoes environmental test at Sperry. Story on p. 27



MISSILE in the news is the IRBM *Thor,* which was scheduled last week to have made first *Discoverer* shot.

INSTRUMENTS that measured radiation belts in *Pioneer* space probe. See p. 18



FIBERGLASS astrodomes to protect instrumentation are now on the market. See p. 33

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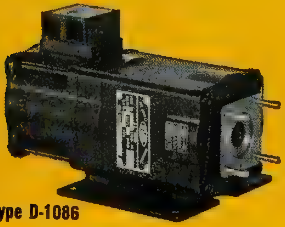

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Type D-978

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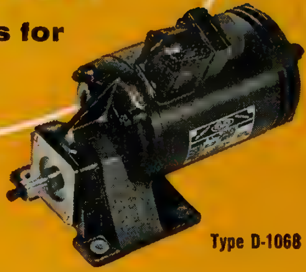
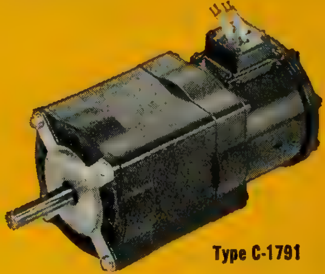


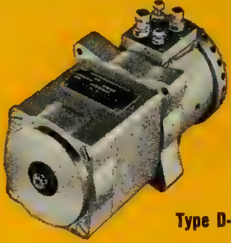
Type D-1068

For missile applications. 2.75 HP AC motor, 3140 rpm at gear box, continuous duty, 200 volt, 400 cycle, 3 phase. Power factor: 83%. Overall efficiency: 76%. Weight: 11.25 lbs. Meets MIL-SPEC M-7969A (ASG).



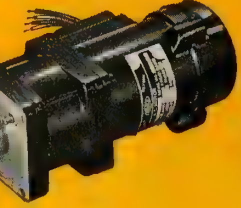
Type C-1791

For ultracentrifuge application. 1½ HP AC motor, 12,000 rpm continuous duty, 115 volt, 60 cycle, single phase, fan cooled. Weight: 12 lbs.



Type D-1025

For motor truck turbine engine applications. Starter-generator, weight 14.5 lbs. As starter: breakaway torque 220 in-lbs, terminal voltage of 20 volts. As generator: 40 amps continuously with intermittent peaks up to 80 amps at 28 volts.



Type C-1874

For actuator applications. 400 cycle, 3 phase AC motor and clutch. Intermittent duty, 12,000 rpm on 200 volts, 650 watts output. Weight: 4.5 lbs. Meets MIL-SPEC M-7969A (ASG).

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washington countdown

New House Space Chairman . . . will be Rep. Overton Brooks (D-La.) presently second-ranking member of the House Armed Services Committee. Brooks will replace Rep. John McCormack (D-Mass.) the House Democratic Majority Leader, who has decided to step down.

Three months after . . . organization of NASA, the nation still has no long-range space program, Dr. T. Keith Glennan, head of the civilian space agency, has announced publicly.

Navy and Army are up, AF down . . . according to best estimates as to how FY 1960 defense budget will be divided among the three services. Compared with current budget, Navy will get an increase of about $300 million, Army will get about $300 million less. The $40.9 billion budget will be divided approximately as follows: Air Force, $18.6 billion; Navy, $11.8 billion; and Army, $9.3 billion; with an additional $1.2 billion for the Office of the Secretary of Defense. Congress added $1 billion to FY 1959, but the Administration has decided to hold nearly all of it until July 1, thus holding down current expenditures and the 1960 budget.

Congressional opposition . . . already is shaping up against the Administration's proposed budget. Senate Leader Lyndon Johnson of Texas, has criticized it and the nation's space programs. He said there is no "substantial increase" in defense funds, and "we're not going farther, faster" in military and space programs.

Four more *Polaris* subs ordered . . . just before New Year's (bringing the total to nine) will use up some of this additional money provided by Congress, but very little of the $600 million unfrozen will be spent before July 1. First warheads are expected to have a nuclear warhead equal to about 300,000 tons of TNT, and later models to equal a million tons of TNT.

Does Macy tell Gimbel's? . . . contractors working on the WS-199 recently prepared press releases on the project. AF approved, but they were stopped cold when they hit Missile Boss Holaday's office. Reason: he reportedly didn't know an air-launched IRBM project was in the works by Air Force.

RAND is denying . . . a statement semi-officially attributed to it that Russia will have 300 ICBMs within 18 months. Not its statement, belief or position, RAND says.

Ubiquitous Murray Snyder . . . DOD's assistant secretary for public affairs, was first to move under reorganization directive. He informed services he was taking over direction and guidance of public affairs for the unified and specified commands, with direct communications thereto, and immediately called "the first world-wide unified and specified command information conference for Jan. 12-13." Snyder has not yet replied to service queries if he intended controlling release of all command information down to such things as military police incidents, aircraft accidents and supervising base histories.

First *Thor* squadron . . . in England will be operationally ready in February, according to Maj. Gen. Bernard Schriever. *Thor* is 50% reliable now, he added, will soon be 80-90% reliable. *Atlas* will be operational by mid-1959, he said.

Navy is still boiling . . . mad about cancellation of the *Regulus II* program. At a budget meeting of all service chiefs, Navy was told it had to cut, and cut in big chunks. All longer range air-breathing missiles, it was jointly agreed, would go. Navy reluctantly put the axe to *Regulus* assuming the across-the-board understanding would prevail. Realizing an interim weapon is needed until *Polaris, WS-199* or some comparable system is ready, DOD reportedly then threw additional money to continue the *Mace*. The decision in favor of *Mace*, according to one source, was made solely because *Mace* operates at a higher altitude. The Navy's $200 million cut was split down the middle in killing the Seamaster program and the *Regulus II* systems.

This missile component is typical of structures now in production.

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industry countdown

New *Polaris* submarine . . .

to be built by General Dynamics, will be 5600 tons heavier than earlier models of the nuclear-powered submarine. Sub, with a price tag of $105 million, has been designed from the hull up to carry missiles. Advanced design work and parts procurement has been in progress for some time.

Army awarded Martin . . .

a $54 million contract to continue R&D of the *Pershing*. Martin will provide engineering, research, laboratory and testing facilities and a support system for development of the second-generation weapon at its Orlando facility. *Pershing* is a combined industry-military development concept. Engine tests have been made.

Lunar probe instrumentation . . .

developer, NOTS China Lake, has achieved remarkable successes in the space work assigned to it. The group is also part of the development team for the ARPA navigational satellite.

Army awarded Sperry . . .

an additional $22-million contract for continued development of the *Sergeant*. Work on the 30-inch diameter solid propellant missile will be done at the Utah plant. $13-million is for production of missiles for testing purposes, and $9-million for R&D.

Hawk production in Germany . . .

will probably involve the electronic equipment for the missile while other hardware production will be the responsibility of France and Italy, if the planned NATO program is realized. Germans are highly interested in the British Bristol *Bloodhound* SAM for part of their air defense system.

Satellite mail delivery . . .

anywhere on the globe is under study by RCA. Brig. Gen. David Sarnoff, chairman of the board, reported that detailed studies have been made of possible uses of a satellite as an orbital post office for space mail delivery between the U.S. and Europe.

Grumman, Republic and Fairchild . . .

will work together whenever advisable on new astronautics projects to provide inter-exchange of compatible resources. The companies will collaborate on proposals for missile and space projects with ARPA and NASA.

Fairchild is slashed again . . .

with cancellation of the development of the J83 high thrust-to-weight ratio turbo-jet engine. It was originally slated for the *Goose* surface-to-surface long-range decoy missile that was cancelled last month. Fairchild plans to lay off more than 2000 employees.

Battery of *Lacrosse* missiles . . .

has been selected by the Canadian Army as a part of a new modernization program. The battery, including four launchers, associated fire-control equipment, and 12 missiles, initially will cost an estimated $1,198,000. Recurring annual cost; to replace missiles used in training will be $360,000.

Hercules Powder Co. . . .

has completed negotiations for purchase of the Young Development Labs of Rocky Hill, N.J., a manufacturer of filament-wound, glass-fiber-reinforced plastic materials. Young Development has worked with Hercules for many years supplying motor hardware for solid propellant rockets.

Martin has set up a new corporate office . . .

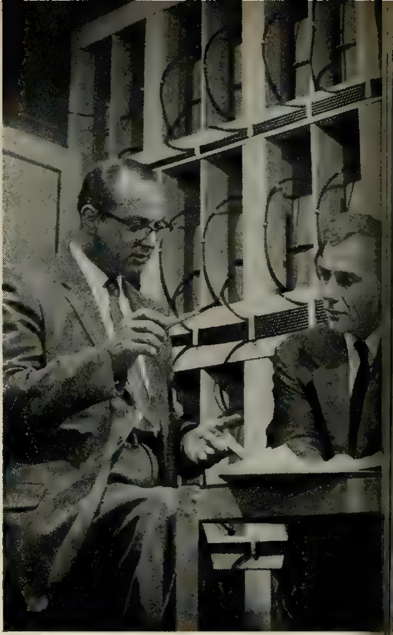
Manager of Electronics Requirements, for coordinating future missile business.

$10.5 million expansion . . .

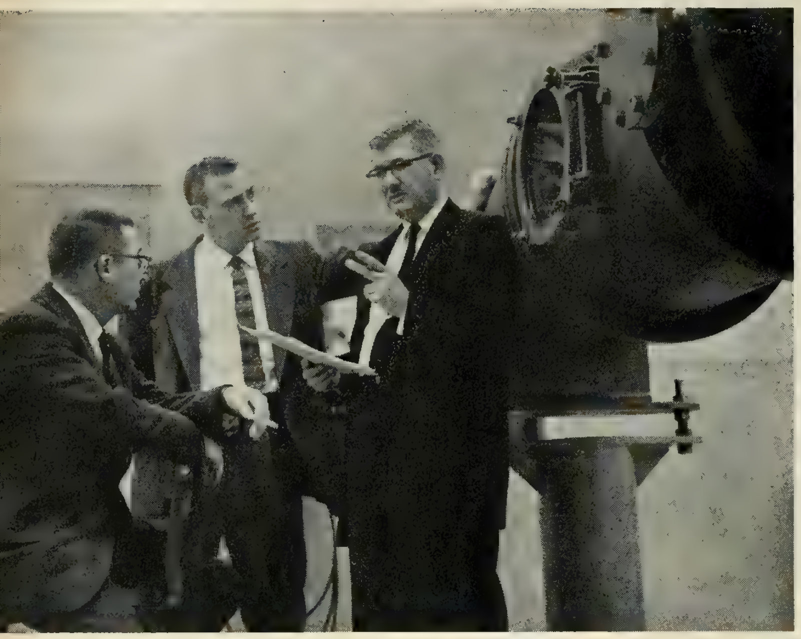
program of Ramo-Wooldridge, a division of Thompson-Ramo-Wooldridge inc. will be on a 90-acre site in Canoga Park, Calif. First six units are to be completed late this year.

Merger is planned . . .

between Texas Instruments Inc. and Metals and Controls Corp. of Attleboro, Mass., on an exchange-of-stock basis.

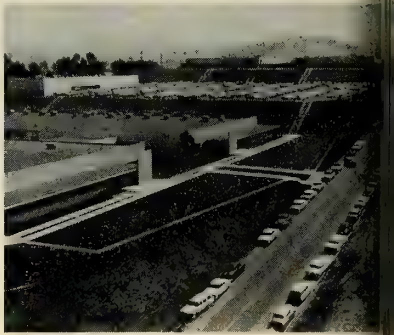


(right) Part of giant capacitor bank used to fire "hotshot" tunnel. Bank is capable of 5 million kilowatt jolt.



(above) Lockheed's "hotshot" tunnel — only one in private industry.

(right) Research and Development facilities in the Stanford Industrial Park at Palo Alto, California, provide the latest in technical equipment.



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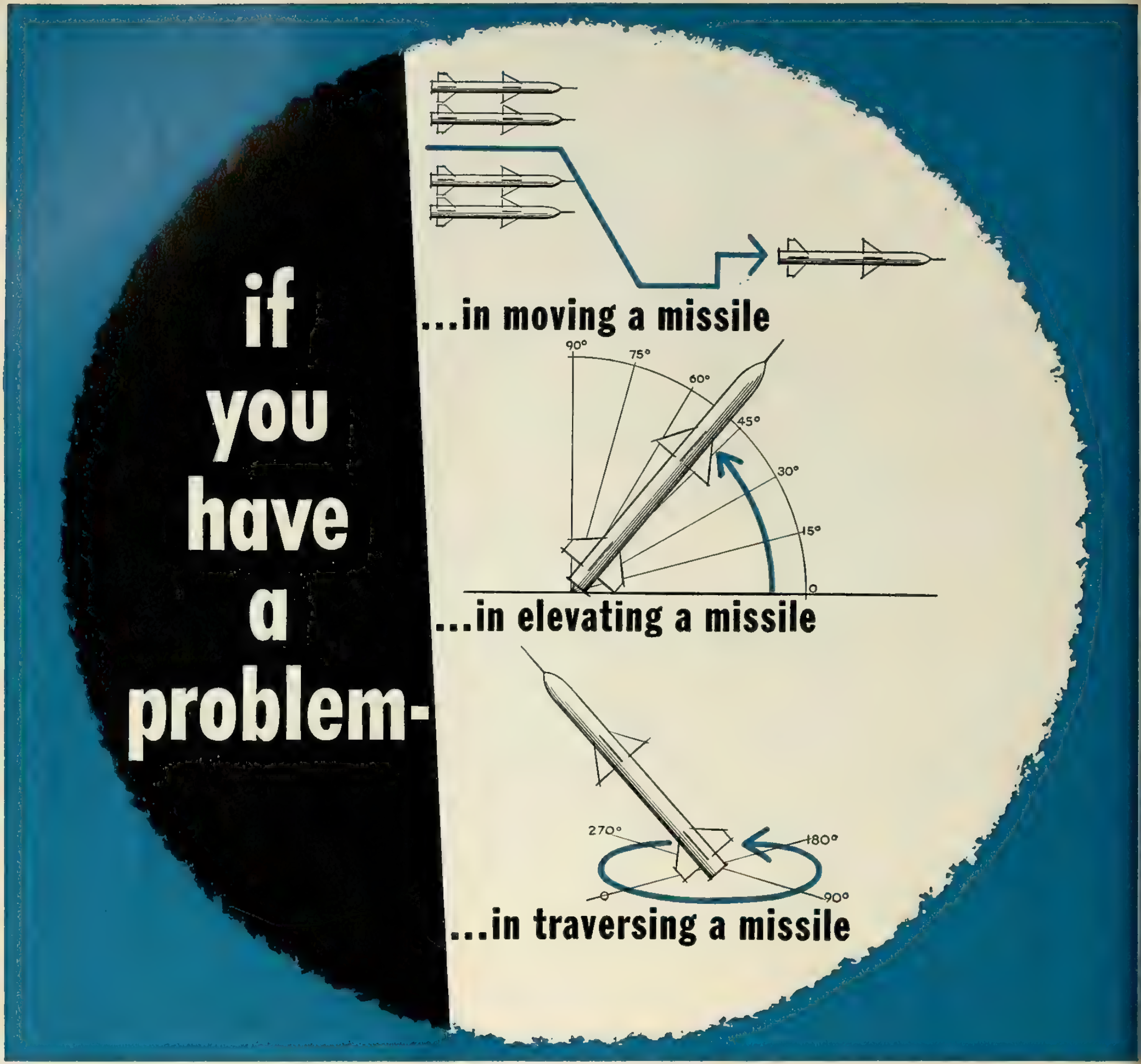

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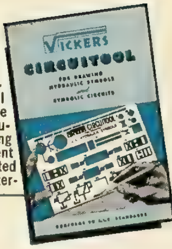

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ANUARY 12, 1959—VOL. 5, NO. 2

missiles and rockets

MAGAZINE OF WORLD ASTRONAUTICS

Congress Set for Renegotiation Fight

Industry groups press for elimination of 17-year-old Act labeled costly and discriminatory. But they will settle for relaxation of objectionable features.

Pentagon dislikes system but can't say so publicly. Saltonstall bill would exempt many contracts and boost incentive for manufacturers.

by E. E. Halmos

WASHINGTON—Sen. Leverett Saltnstall (R. Mass.) is expected soon to ıtroduce a bill aimed at loosening ome of the most unpopular controls of ıe World War II-born Renegotiation ıct.

A stiff battle is already shaping p, even though Congress has only ecently opened its doors for new busiess. Already U.S. industry forces have een meeting together and with their llies on Capitol Hill to map strategy.

Saltonstall, a member of the Senate rmed Services Committee, is readying egislation which would exempt from enegotiation:

1. Any contracts (or procurement) ntered into after formal advertisement r bids;
2. Contracts entered into after ompetitive negotiations;
3. Contracts which include inentive clauses.

Near the end of the 85th Congress, st summer, industry—with missile anufacturers playing an important art—won a minor victory by getting ongress to extend the Renegotiation ct by only six months, instead of the vo years originally proposed.

Congress promised to make an exaustive study of the 18-year-old law, efore considering new legislation this ear. Hearings may get underway by ıe end of this month.

The issue:

Industry concerned with defense—nd that cuts a broad swath through ıe entire U.S. industrial community—els that renegotiation is a wartime easure that has become, in peacetime, othing more than a retroactive tax. orse, it feels that renegotiation now ctually deters efficient production, educes incentive, and in fact makes efense more and more costly to the merican taxpayer. Worse still, it sees ıe law being used as a broadsword to enforce the power of government agencies over the U.S. economy.

Spearheading the proponents of the law is the Renegotiation Board itself, headed by Thomas Coggeshall, which feels that the law is a guarantee against excessive profits by industry at the taxpayers' expense.

The armed forces themselves—beneficiaries or victims of the system—are in the middle, and trying carefully to steer a course that will antagonize no one. Privately, government contracting officers feel that the law is now, in effect, a criticism of their own abilities. The need for renegotiation implies, they feel, that the men who made the original contracts weren't competent to obtain fair prices from the contractors.

The Controversy in Brief

- **Renegotiation began . . .** in 1941 when the U.S. was in a hurry for war materials. Congress passed the act as a safeguard against exorbitant profits. It has been in effect since, except for 1946-47, but is slated to die this year. The Renegotiation Board may approve profits or require manufacturers to return part of them. There's no appeal except to Tax Court.
- **Proponents claim . . .** the law is needed to prevent excess profits at the taxpayer's expense.
- **Industry complains . . .** the present set-up ties up profits pending Board rulings, hits at incentive, hurts small business.
- **Unhappy Pentagon . . .** contract negotiators feel the system reflects on their competence.
- **Opponents contends . . .** industry and government now have the know-how to set fair and accurate prices; the government has other safeguards against excess profits anyway, and more incentive would benefit both industry and taxpayer.
- **Likely outcome . . .** is a compromise—not wiping out the law but creating exemptions.

The fact is that industry doesn't expect to achieve a complete knockout, although the expressed aim of its actions before Congress is the complete elimination of the Renegotiation Act. Actually, industry will be satisfied this year if it can succeed in easing the act's provisions to allow more freedom.

- **What is it?**—The whole question of renegotiation is one that is only hazily understood by the general public, and it is even hazy to many industrial people who are affected by it.

Briefly, its history goes back to 1941, when—under the stress of wartime conditions—the U.S. government found it necessary to enter into thousands of contracts for war materials in great haste. There was no time for careful negotiation, estimating or studying of previous experience in producing these items. In fact, there was no experience at all in manufacturing some of the items. In other cases, the nature of the procurement was so secret—and the need for speed so great—that it would have been impossible to advertise for public bidding.

Congress, worried by the possibility of exorbitant profits under this stress, passed the Renegotiation Act. It was actually a provision for an open contract—for re-examination at a later date of the actual costs of producing the item in question, and readjusting the price paid by the Government for the item, if it was found that the original estimates were out of line.

What happens is this: At the end of his fiscal year, the defense contractor who has handled $1 million or more of defense business must submit to a district Renegotiation Board (now located in New York, Chicago and Los Angeles) a complete and complex statement, reporting and justifying his earnings and the prices charged. The regional board reviews these figures, makes a ruling as to whether the profits shown are reasonable, or whether the manufacturer must return some of his profits to the government. Regional board actions are subject to review of a Statutory Board, headquartered in Washington, under Mr. Coggeshall's chairmanship.

The Statutory Board's actions can be appealed—but only to the Tax Court, whose decisions, in turn, cannot be appealed to regular civil courts.

The law was in effect continuously from 1941 through 1945, lapsed from 1946 to 1947, then was reinstated and has been in effect since 1948.

• **Long time no pay**—The whole process of submission of evidence, board review and decision and final determination has seldom taken less than two years, and more normally has taken up to four years.

Here is one of industry's major complaints. This long-drawn-out process has meant, in real terms, that profits earned in any one year must virtually be segregated for a period of two to four years ahead, because the workings of renegotiation may result in the manufacturer having to return all or part of the money.

As a result, money that would be plowed back into the business, to improve facilities or be devoted to research, or that might be returned to investors as dividends, is frozen until the slow grinding of government machinery frees it. Worse still, the profit may not even exist—the government may take it all back.

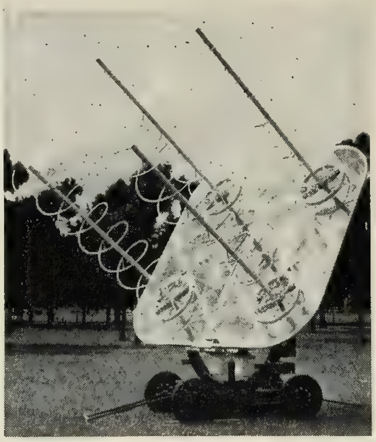
In the years 1952-1954, as one example, Boeing had to refund a total of $27.5 million of its total earnings as result of decisions of the renegotiation board.

• **No incentive?**—Probably most aggravating point to manufacturers—and to the armed services—is the fact that incentives for efficient work are apparently meaningless in the light of renegotiation provisions.

For example, many of the contracts entered into by the government agencies provide an incentive for manufacturers, if they can produce the item at better than the agreed-upon costs. For example, a manufacturer, after negotiation and careful consideration of his costs, may agree to produce an electronics item for, say $120 each.

If he is very efficient, watches his operations and his costs, he may be able to produce the item for, say $100. His contract with the government encourages him to do this—it offers him 20% of the savings he effects as his reward for efficiency. The government, in turn, benefits to the tune of 80% of the savings.

Atlas Antenna



RADIQUAD ANTENNAS are being used to send and receive messages from the *Atlas* satellite at strategic spots around the U.S. Built for the Army Signal Corps by Radiation, Inc., of Melbourne, Fla., this antenna will transmit and receive to separate telemetry and message channels simultaneously.

However, provisions of these incentive-type contracts limit his actual total profit on the item to 12%. And then, renegotiation some years later may force him to give up the incentive earnings—as has happened on several occasions.

The result, say industry proponents, is that there is no incentive to produce more efficiently. If you agree to produce an item for $120, see to it that it does in fact cost that much. Then you can collect—with some certainty—the profit you've figured, without so much chance of losing it all.

• **Small business hurt?**—Another result, say industry people, is damage to small operators. And the missile field, in particular, is largely made up of small operators.

Reason: One of the criteria for determining whether a profit has been excessive is the net worth of the prime contractor—how much he has invested in physical plant and equipment.

Thus it might pay a prime contractor to acquire plant and equipment to do work that he might otherwise let out of his shop on subcontract. Every bit of equipment he himself owns is countable as part of his net worth. So he may save on the renegotiation consequences if he does more work himself, even if it is uneconomic from any other viewpoint for him to do such work.

A second reason is of course obvious: If the prime has trouble collecting his money, the subcontractor must wait that much longer for his share—or at least his payments are uncertain.

From the viewpoint of the armed services, there is another serious point: If renegotiation is necessary now, it means in effect that the contracting officers are considered to be incompetent. If they can't be trusted to sign contracts and negotiate contracts that will produce the best possible results at lowest cost for the government, then renegotiation is necessary.

• **Answers**—Industry in general—and the Aircraft Industries Association, the Electronics Industries Association and the U.S. Chamber of Commerce have spearheaded the attack—makes these points in its arguments against renegotiation:

1. During and since World War II government agencies and industry both have developed sufficient know-how to arrive, in most cases, at fair profit figures for production of defense materiel.

2. Among the devices available to the government, as a guard against excessive profits, is the cost-plus-fixed-fee contract, worked out successfully during the war.

3. Industry should be allowed the incentive of more profit for efficient operation.

4. The defense industries—particularly those concerned with aircraft and missile production—have been unfairly penalized in relation to other industries, by arbitrary actions of the Renegotiation Board, which has cut profits down below that of general industry, in relation to net worth.

5. Existing laws such as the Vinson-Trammel Act put a ceiling on defense profits, anyway.

• **Realities**—No one believes that the result of this year's fight in Congress will be complete elimination of renegotiation. The subject is too popular politically, for one thing. And no one denies that there have been flagrant examples in some industries of excessive profits at government expense—although those examples are far from the majority.

What seems reasonable to expect is a compromise, such as that embodied in the bill being readied for introduction by Senator Saltonstall.

The result has to be a better climate for business, better value for the dollar, say proponents.

They have a long, tough fight ahead against opponents who claim, in effect, that industry is not to be trusted.

Bomarc Engines Are Tested at Marquardt Lab

Huge facility stores fifty tons of air for supersonic testing at altitudes near 200,000 feet

by Raymond M. Nolan

VAN NUYS, CALIF.—In all *Bomarc* rings from Cape Canaveral in 1958, ere was not one abort due to ramjet ilure. One basic reason for this suc- ess is the Jet Laboratory operated by Iarquardt Aircraft Co. for the *Bo- arc* engine development program.

The laboratory, modernized and edicated last fall, is one of the world's rgest and most powerful facilities for sting supersonic air-breathing engines id components for missiles.

The facility, jointly financed by the SAF, the Navy and Marquardt, has een operated since 1949 by the com- iny. Prior to its modernization it was major element in the development of e propulsion system for the *Bomarc,* owered by two ramjets. More than)0 flights have proved that the *Bo- arc* propulsion has reliability of eater than 98% with 95% confi- ence.

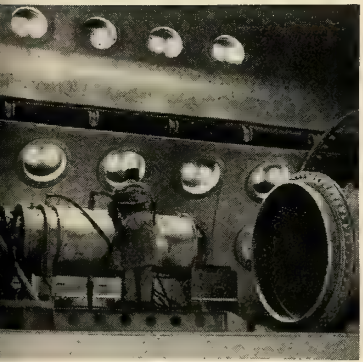
The modernized laboratory permits sting of engines 5 to 6 feet in di- meter at altitudes approaching 200,-)0 feet and Mach numbers of 4½ capable of being extended to Mach 7. The laboratory now includes eight specialized engine test cells, complete fuel controls and systems testing facilities for both ambient and environmental conditions, as well as accessory testing capabilities and smaller-sized research-type test installations. This week's m/r cover picture and photographs on this page were taken in Cell No. 8 in the laboratory.

The facility has several unusual features. One of these is an air storage system for the large quantities of air needed for supersonic ramjet testing. A total of 100,000 pounds of air is stored in 10 vessels that range in weight from 55 to 110 tons each.

As this air can be blown down in less than a minute—a satisfactory figure for ramjet testing—it would require a compressor installation well in excess of 200,000 hp to provide a similar continuous capacity. The actual compressors installed total 4250 hp, making an overall delivery system of approximately 10 per cent of the ordinary cost.

• **Heaters used**—Two large heaters are used to simulate the stagnation temperatures at very high speeds. The first heater, a part of the original laboratory, provides temperatures up to 700°F and has been in constant use during the development of the *Bomarc* engine. The other heater, installed as part of the modernization program, provides air up to 1200°F. The major exchange surfaces on the newer heater are made from chromized steel, reportedly the first time this material has been used in a large heat exchanger. This process changes the outer surface of the material to nearly pure chromium, giving good corrosion properties.

In the exhauster system, five J-47 turbojet engines are used to drive the turbines of 10 J-33 turbojet engines. The turbines supply more than 30,000 shaft hp to their compressor sections, which in turn exhaust the air from the test cells. For large mass flows at medium altitude, the system operates as a single stage. However, for extreme altitudes it is operated in a multistage configuration.



BSERVATION PORTS are visible in st cell.

RAMJET ON stand as seen through exhauster.

TECHNICIAN READIES ramjet for testing. Facility can change engine angle-of-attack during testing.

Polyurethane-Polysulfide Battle Is Raging

Urethanes looking up in fuel-binder struggle. Industry expecting to get I_{sp} of 275-300 seconds in near future

by Alfred J. Zaehringer

DETROIT—What's new in the fuel-binder battle of solid propellants? The large grain struggle—particularly for ballistic missiles—hinges on polyurethane versus polysulfide. And industry advances are remarkable to say the least.

Let's talk a little history:

Possibly the biggest single advance in solid propellants was made during World War II at CalTech's Jet Propulsion Laboratory. The fuel-binder of the old asphalt-perchlorate thermoplastic combination was replaced with a polysulfide polymer.

This move permitted internal burning grains and allowed the use of thin-wall combustion chambers. The solid propellant people were then given a large increase in mass ratio.

Solids could finally compete with liquids. Then, the potassium perchlorate oxidizer was replaced by the higher energy ammonium perchlorate. By and large, the ammonium perchlorate (AP) oxidant-polysulfide fuel binder has eliminated the composite solid propellant picture. The liquid polysulfide polymers (LP) ushered in the era of castable propellants that could take severe temperature cyclings.

On this wave of increasing AP-LP applications, Thiokol Chemical Corp. was able to ride up—possibly to the top of the solid propellant heap.

But despite the good features of AP-LP propellants, there were several disadvantages:

1. High polymer cost and relatively low volume.
2. Polymer production tied to one manufacturer.
3. Polymer production critically related to sulphur availability.
4. Long cure times.
5. High molecular weight exhaust products.
6. Objectionable sulphur compounds in exhaust for some applications.

It is known that Aerojet-General Corp. has done extensive work with the low cost polyesters. It is further suspected that Aerojet's Aeroplex propellants of today are based on polyesters. One source states that Aerojet is using the Rohm & Haas Paraplex polyesters.

Paraplex consists of the reaction product of a dihydric alcohol with a dibasic acid dissolved in monomeric styrene. Atlantic Research Corp. has done work on vinyls, Shell Oil Co. may be working on epoxies, and American Rocket Co. on the poly nitrogens. Goodrich, Phillips, and Standard Oil are all working with various synthetic rubbers or elastomers as solid propellant fuel-binders.

An elastomer can repeatedly be stretched to 150% or more of its original length and snap back to its original state. However, despite "hot" claims and "no comments" most, if not all, solid people are taking a serious look at the polyurethanes.

• What are polyurethanes?—The polyurethanes were born in Germany in the 1930's. After the war, the German Farbinfabriken Bayer AG was particularly active in developing new urethane foams, coatings, adhesives, and elastomers. The urethanes finally came to the U.S. in the 1950's.

Chemically, a polyester couples with urethane links (a diisocyanate) to form a polymer. The cross-linking is accomplished by means of heat or catalysts. However, if excessive diisocyanate is present, the addition of water will give off carbon dioxide gas. This CO_2 is desired to produce foams but is undesirable for solid propellants. One of the requirements of an ideal solid fuel-binder is that no reaction products be given off in the formation of the solid polymer. Here is one area where the application of urethanes to solid propellants could be troublesome.

In general, the urethane elastomers are solvent-resistant, have good oxygen content (important for fuels), and display excellent physical properties at low temperatures (-70°F) and at temperatures up to 300°F. The high temperature properties (Figure 2) are especially important.

Solid rockets are being used for vernier control of ballistic missile warheads. Here the solid propellant will also act as a heat sink where high temperature resistance is desirable. Present high end temperature specifications call for about 170°F but the handwriting on the wall indicates that solids will have to be able to take at least 212°F within the next two years. B 1962, solids must be able to withstan 250-300°F for certain applications.

• Two types available—The ela tomeric urethanes are rubber-like gum when cured. They are available as l quid polymers or solids. The liqui polymers can be catalyzed and mixe with oxidizer to give composites of castable or extrudable nature.

The solid urethanes are much lik natural or synthetic rubber which ca be compounded with oxidizer on a tw roll mill or in a Banbury mixer. Var ous fillers (the oxidant is the filler) ca also act to reinforce the elastomers.

Plasticizers (such as TCP) coul also be added to ease processing or t impart special properties to the finishe propellant (such as high-temperatu anti-oxidation or low-temperature flex bility).

Another advantage of the urethan is high adhesion. Being very good a hesives, such propellants can give cas bonded grains. Also the fact that th polymers are thermosetting (viz., d not melt when heat is applied) make them suitable for internal-burnin grains.

For safety and ease in processin ammonium perchlorate urethanes woul probably have to be handled as liqui castables. It is conceivable that ammo nium nitrate urethanes could be mille for propellant production. Phillips, fo example, has successfully hot, dr milled ammonium nitrate and syntheti rubber. Ammonium perchlorate, on th other hand, is quite friction-sensitiv when mixed with fuels.

• Ballistic advantages—There ar two big thermochemical advantages i the use of the urethanes:

1. Possibility of incorporating oxy gen into the polymer molecule.
2. Nitrogen which can go to th free state.

The first, oxygen incorporation, i especially important. For most organ ics, some 85-90% of the propellant, b weight, must be oxidant for stoichio metric conditions. Any non-oxidize oxygen which can be built into the fue molecule will help.

Then, there is talk of adding metals (aluminum, magnesium, or boron) or even the boron hydrides to the fuel to increase heat content. With ordinary composites, the propellant formulator cannot stand too much additives addition without harming the already critical physical properties of today's oxidizer heavy solid propellants.

Simply stated, to take full advantage of higher heat content fuels without ruining propellant physicals, more oxidizer must be added. It would appear advantageous to get the fuel-binder to do some oxidizing also. Aerojet is now reported working on this very approach.

Next, the nitrogen in the molecule could go to free nitrogen N_2 with a molecular weight of 28. This compares with the 32 of free sulphur or 64 for SO_2 which are among the reaction products of today's polysulfide propellants.

Dropping molecular weight can be just as important as increasing heat content. Factually, to make significant performance advances, heat content should go up and molecular weight of exhaust should come down.

Then, the cross-linking nature of the polymer (which can take place at room temperature with the proper catalyst) could allow the incorporation of high energy components such as the nitro (NO_2) or nitrate (ONO_2) groups as oxidizers or the amine boranes (dimethlyamine-borane, trimethylamine-borane, or pyridine-borane) to increase the heat content of the fuels.

The latter is viewed as especially interesting since the active hydrogen amines are used to cure the polymers. Callery Chemical is promoting the amine boranes as polymerization catalysts. Thus, more stable boron propellants could result by utilizing the cross-link method rather than simple mechanical incorporation.

• **Who is working on urethanes?**—Right now the field is far from stabilized. Here are some of the activities that have been revealed or implied:

1. **Aerojet-General**—Reportedly working hard and furiously on polyurethanes—particularly with ammonium perchlorate and metal addition on the *Polaris* propellant program. Aerojet supposedly has hit the 270 I_{sp} mark with the urethanes. Significantly, General Tire & Rubber, Aerojet's parent firm, is pilot plant producing the "Genthane" polyurethane elastomers at its Akron Chemical Division but is also looking hard at the polyether-polyurethane field.

2. **Atlantic Research**—This solid propellant firm is believed to be working on polyurethane solids. It has openly advertised for urethane scientists. Whether it has given up its vinyl program is not known, however.

3. **American Rocket Co.**—Working with the polyether-polyurethanes to form castable solids.

4. **DuPont**—Has considerable patent holdings involving the use of isocyanates for polyurethanes—particularly for foams and other commercial applications. Apparently no propellant interest at the present time.

5. **Monsanto**—This is the firm to watch. Monsanto has a longstanding interest in solids (producer in World War II and R&D activities during the Korean war). It has joined with Bayer of Germany to form Mobay Chemical to exploit polyurethanes. Mobay's solid urethane elastomer Vulkollan has shown an alongation of 600-800% (natural rubber is about 550% tops). The polymer is a free flowing, thin liquid which might make an ideal fuel-binder.

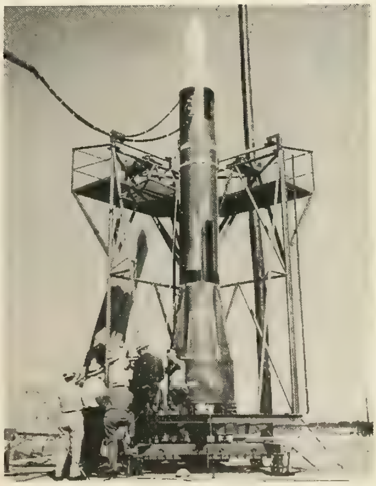
6. **Reichold**—Producing polyesters for polyurethanes. Apparently no solid propellant interest.

7. **Rohm & Haas**—This polyester producer operates a solid propellant R&D laboratory at Redstone. May be on an urethane solid propellant evaluation program.

8. **Thiokol Chemical**—Producing the ZL polymers containing diisocyanates for foam applications. It has looked at polyurethane solids, and sees no overall advantages over polysulfides. However, probably Thiokol is quietly doing much R&D work in the back end.

9. **Wyandotte Chemical**—Use of its polyols (polyoxyalkylene glycols consisting of blocks prepared from propylene and ethylene oxides) would permit significant cost reduction in the polyurethanes for solids. At the present time this is an unknown factor in the solid picture other than a present supplier of polyols.

Polaris Is User



AEROJET IS WORKING hard on polyurethanes particularly for its *Polaris* program.

• **Ballistics good**—Reports have it that Aerojet has hit 270 with its polyurethane propellant—probably ammonium perchlorate. Whether this is theoretical tops, actual test stand (corrected for altitude), or is with additives is not known.

One report has it that an all ammonium nitrate polyurethane propellant has hit an I_{sp} of 210 sec without high energy fuel additives at sea level conditions in test stand runs.

This—if true—means some 10-20 seconds over the performance now realized with present fuel-binders. And, it means that ammonium nitrate solids with high energy additives could compete with the present ammonium perchlorate combinations which are giving about 225 seconds in actual test stand runs at sea level conditions.

It is felt that ammonium nitrate can give an I_{sp} of about 240-250 seconds with the envisioned high-energy additives. Probably an ammonium perchlorate-polyurethane combination (without additives) could give an actual I_{sp} of 240-250 seconds.

However, lithium perchlorate or nitrate might be able to go a little higher but not much more; and it might be possible to get a lithium propellant to 275 I_{sp} with high energy components.

Burning rates of the urethane propellants will probably tend to be higher than with the polysulfide polymers.

• **Conclusion**—Summarizing, the urethane solid propellant picture looks like this:

1. Ballistic properties. Good to excellent. Possibility of introducing more oxidizer and/or high energy fuel components.

2. Availability. Growing and much better than polysulfide. Independent of critical sulphur during war.

3. Cost. On a par with polysulfides but dropping radically. With polyethers. They are almost on a par with the vinyls or polyesters which are among the lowest cost, high volume polymers in production.

4. Heat stability. Good to excellent.

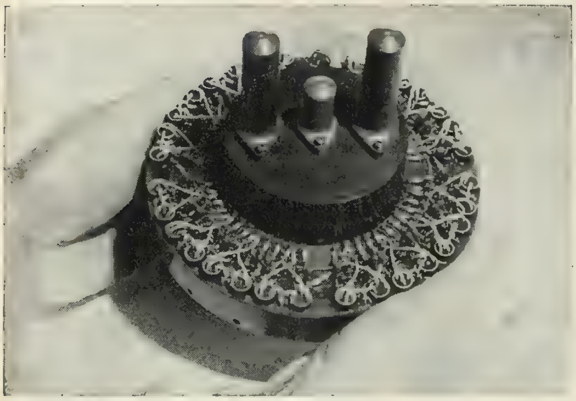
5. Physicals. Good to excellent.

6. Storage. Long term conditions unknown.

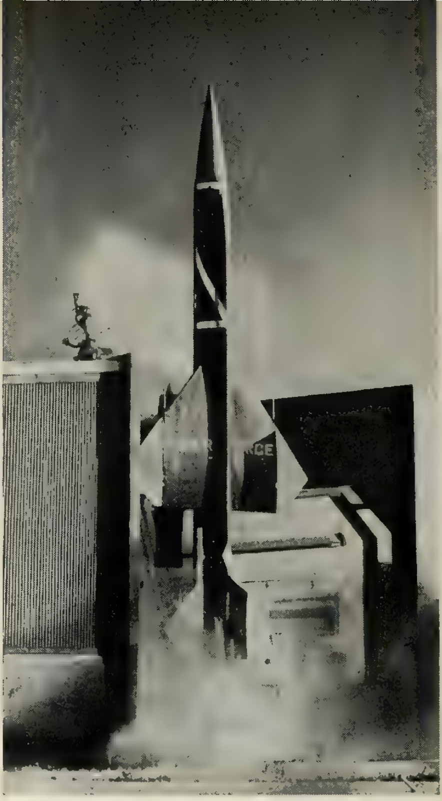
7. Processing. Fast. Involves use of toxic materials.

For these reasons, polyurethanes offer better than 250 I_{sp}. In fact, with molecular modification, it may not be too long before the U.S. has solids giving an I_{sp} of 275-300 seconds.

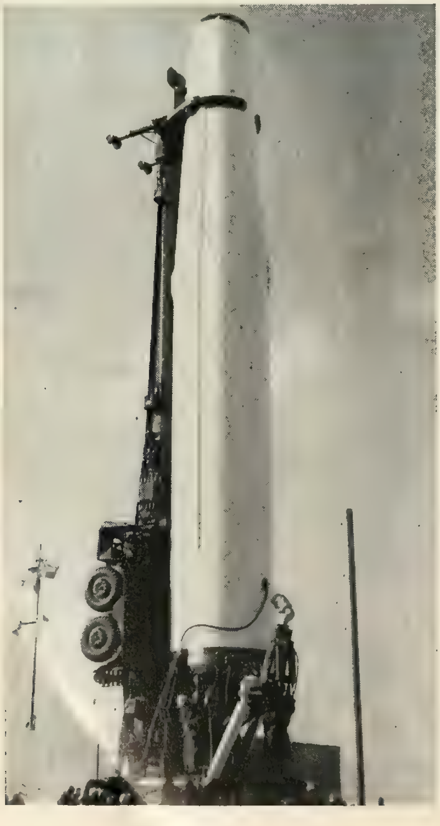
missiles in the news...



INSTRUMENTS THAT measured the two radiation belts during the flight of *Pioneer III* on Dec. 6-7. The two Geiger-Mueller tubes measured the intensity levels.



THE TENTH flight of the SAGE series recently was completed by *Bomarc*. The Air Force surface-to-air missile has racked up an impressive score.



***Thor* IS ERECTED to vertical launch position by its transport erector on Vandenberg pad 75-1 as the protective shelter moves away.**

THE FIRST operational *Thor* IRBM fired Dec. 16 from Vandenberg AFB was minus the fins used on earlier missiles.

When men push off for Space, they will need the absolute accuracy of inertial and stellar-inertial guidance systems to navigate in the trackless void. Working with the Air Force, Autonetics has spent 12 years bringing both to their present high state of development. Autonetics made America's first successful flight test of an inertial guidance system in 1950. Since then, more than 800 successful flight tests have demonstrated the reliability of a series of ever-improved systems. Today Autonetics has the basic know-how and hardware America needs for Space navigation.

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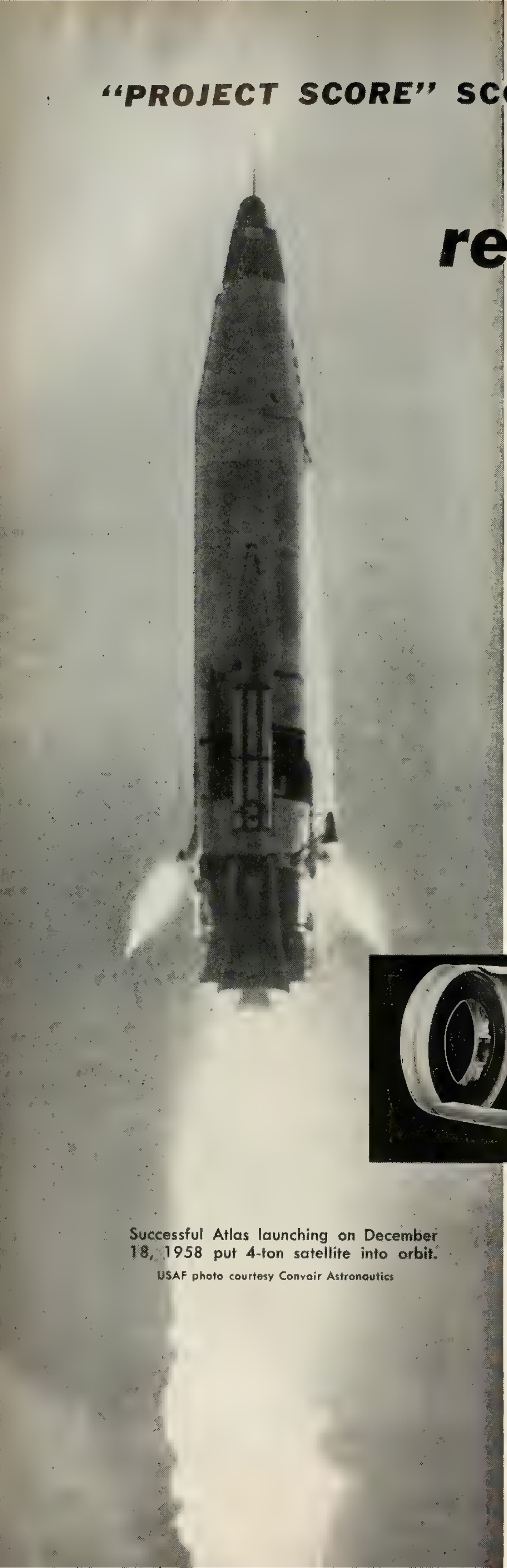


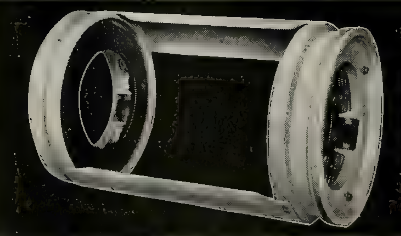
reliability is key to success of giant satellite!

Lord mounting systems played critical role in record-breaking feat

The Advanced Research Projects Agency of the Air Force and Convair Astronautics, prime contracto can take pride in this latest Atlas accomplishment.

It is no coincidence that Convair chose Lord high-performance mounting systems for reliable protection of sensitive electronic control equipment.

This giant leap toward the stars demonstrates Lord capabilities to produce custom-designed mounting systems of uncompromising excellence.



High-performance mounting system for Atla protects electronic packages by providin protection from destructive shock, vibratio and noise. It is a product of Lord's integrate systems engineering approach.

Successful Atlas launching on December 18, 1958 put 4-ton satellite into orbit.

USAF photo courtesy Convair Astronautics

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Lunik Becomes Solar System's Tenth 'Planet'

Indications are Russians may have hoped to hit moon; exploit demonstrates know-how in velocity, guidance

by Norman L. Baker

WASHINGTON—*Lunik,* the tenth "planet" of the solar system, is slowly pushing farther from the earth as it moves into its orbit as a captive asteroid of the sun.

Seven and one-half months from now, Russia's man-made contribution to the solar system will be somewhere between the orbits of Mars and Jupiter in the asteroid belt.

This week the Soviet "lunar probe" will be at its perihelion to the sun—approximately 91.5 million miles distant. At the apogee of its 15-month (447 days) orbit it will be 214.75 million miles out from the sun and about 120 million miles from the earth.

If and when, its perigee coincides with the position of the earth (some scientists say hundreds, others millions of years), *Lunik* would be pulled back into the gravitational field of the earth. It could, conceivably, be pulled into the gravitational field of Mars or one of the many high-mass asteroids.

According to preliminary calculations by the Russians, the eccentricity of the probe's orbit is 0.1418. The major axis of the orbit is at an angle of 15 degrees and 11 minutes to the major axis of the earth. The plane of *Lunik's* orbit almost coincides with the plane of the earth's orbit.

- **Commemorates Seven-Year Plan**—The probe was launched Jan. 2, undoubtedly to commemorate the start of another Soviet seven-year plan, and possibly as a bargaining tactic for Anastas I. Mikoyan, Soviet deputy premier who is visiting the U.S.

Russia was still receiving data from the payload early last week when it was almost 400,000 miles from the earth. With its radios now dead the chances of locating and tracking the "planet" in the years to come will be very slim.

Lunik's maximum velocity (at perigee) will be about 75,000 mph. This will be the accumulative velocities of the earth (66,700 mph) and the vehicle (velocity of the vehicle plus the "pulling" induced-velocity of the sun). Its maximum velocity (at the time of burnout) was about 90,000 mph with respect to the sun.

Conflicting reports make it impossible to sift out the Russians' original intentions in launching their probe. According to the Russian founder of the International Astronautical Federation, Alexandre Ananov, excessive velocity prevented them from hitting the moon, the intended target.

The marking of the payload with the Soviet symbol, inclusion of a pennant and the inscription "USSR, January 1959"—for possible later verification—and the tagged title of the payload, *Lunik,* seem to verify Ananov's claim. Instruments aboard also substantiate this premise.

Yet the Russians announced within hours of the launching that *Lunik* would pass within 3726-4968 miles of the moon. At 9:59 P.M. (EST) Jan. 3 it passed the moon 4660 miles from the lunar surface (within one hour of the calculated time of 11:00 P.M.). Of course, the fact that it was going to miss the moon would have been known within minutes after learning the burnout velocity and attitude of the final stage. It appears the Russian scientists were prepared for any eventuality.

It is indeed probable that guidance error killed original Soviet intentions of a lunar orbit. In this issue of m/r, (p. 22) LCDR John A. Fahey, Head of the Foreign Language Division of U.S. Naval Intelligence School, points out that Soviet data indicates an intent to orbit at heights of 10 kilometers (6.2 miles), and 50 kilometers (31 miles). He said he expects another attempt in the "very near future" to achieve these goals.

Close orbits of the lunar body, according to m/r Contributing Editor Dr. Albert Parry of the Department of Russian Studies, Colgate University, have been publicly proposed. He quoted an article by Academician N. Barabashev, director of the Kharkov Observatory in the Ukraine.

Barabashov wrote in Izvestia that it was "imperative at this time to compile an exact atlas of the moon's surface."

Two outstanding disclosures of Soviet missile and space know-how resulted from *Lunik's* flight. First, the Soviets undoubtedly once again utilized the *Sputnik* launcher, the T-3 two-stage ICBM, with its tremendous thrust power of about 500,000 pounds.

Also, the accuracy with which they made the calculated close approach to the moon (or missed it by less than 5000 miles) indicates that Soviet guidance problems are not the bottleneck our military experts had thought.

Apparently the Soviet scientists made maximum utilization of *Lunik's* payload of 796.5 pounds. Final stage of the carrier rocket attached to the payload weighed about 3240 pounds. Measurements of the moon reportedly included magnetic field strength, gravitational forces, cosmic ray intensity, sediment evaluation of the lunar craters, properties of the moon's inner strata and optical teletransmission of the moon's surface.

- **No photos**—Although there has been no indication that instruments were aboard enabling the Russian scientists to receive pictures, one report stated *Lunik* was equipped with telescopes for observing the surface at close range. If so, instruments included in the payload were possibly more advanced than the scanner instruments in our *Pioneer* probes.

It was reported shortly after the *Lunik* launching that some Pentagon officials had known of the Soviet probe beforehand, but the report has not been officially verified. Tracking stations at Cape Canaveral were idle as the space probe began its journey toward the moon.

Orders from the Pentagon put the Cape trackers into action the next day. JPL and the Goldstone Tracking Station announced they had received no advance knowledge but made hurried modifications to tracking equipment in time to track the payload the following day.

The United States' tracking station in Hawaii apparently made a signal pick up within 15 or 20 minutes of *Lunik's* launching at 70.2 megacycles when the space probe was still unidentified.

Astronautics Tests

Dec. 30—*Thor* off course shortly after launch was destroyed by range safety officer after 50 seconds of flight. Flight was the 30th firing of the *Thor* vehicle and the 24th of the *Thor* IRBM type.

Jan. 2—*Lunik,* Russia's space probe, launched shortly before noon. Burn-out velocity was approximately 24,500 mph. Arrived 4660 miles from the surface of the moon at 9:59 P.M. (EST) and proceeded on to an orbit around the sun. *Lunik* will reach perigee (perihelion) on Jan. 14 of 15-month orbit. Apogee will be approximately 214.75 million miles from the sun on Sept. 9, 1959.

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USSR Lunar Probes Will Orbit Close to Surface

by LCDR John A. Fahey, USN[*]

WASHINGTON—The Soviet Union has revealed detailed plans for future inspection of the moon's surface. In order to efficiently cover the entire surface of the moon, the Russians will attempt to establish a polar orbit.

Since the orientation of the moon's plane of motion in relation to the sun remains constant, using sunlight the entire surface of the moon could be photographed in four weeks (a lunar month). However, Russian scientists expect that the use of "earthshine" (ten times more brilliant than moonshine) will permit completion of the project in two weeks.

In order to avoid gravitational influences of the sun and planets, Soviet scientists have planned orbits extremely close to the moon's surface. At a given altitude the velocity of a lunar satellite will be almost five times less than the velocity of an earth satellite. This factor will greatly facilitate inspection of the moon's surface.

At a height of 30 kilometers (18.6 miles) objects, 3.8 meters (12.5 feet) in diameter, could be distinguished with the naked eye. However there are certain disadvantages in establishing such a close orbit. A satellite at this altitude will be traveling more than 1600 meters/sec (5250 feet/sec, 3580 miles/hr), and the field of view at a given moment will be about 650 kilometers (404 miles). At this height an object on the moon's surface will remain within the field of vision for six minutes, 20 seconds. Increasing the altitude to 150 kilometers (93 miles) will result in a less detailed observation. An object would have to be 19 meters (62 feet) in diameter to be distinguishable, but the field of view will increase to 1400 kilometers (869 miles) and an object will remain in the field of vision for 15 minutes, 42 seconds.

Soviet data indicate an intention to orbit a lunar *Sputnik* extremely close to the surface of the moon. It is interesting to note that plans call for a supply of fuel in the *Sputnik* for controlling the orbit. Small speed changes will be used to alter an elliptical orbit, to change the plane of orbit, and to decrease the time of passage across the unilluminated surface of the moon.

SOVIET LUNAR PROBE DATA

Characteristics	10 Kilometers	50 Kilometers
Velocity of orbit (meters per sec/feet per sec/miles per hr)	1,674/5,492/3,745	1,655/5,301/3,614
Decrease in velocity of orbit for each one kilometer (0.621 mile) decrease in altitude (meters per sec/feet per sec/miles per hr)	0.479/1.57/1.1	0.463/1.52—1.0
Radius of orbit (kilometers/miles)	1,748/1,086	1,788/1,110
Relationship of radius of orbit to moon's radius, (percent)	100.6	102.9
Circumference of orbit (kilometers/miles)	10,983/6,690	11,234/6,976
Angular velocity (angular seconds per sec)	198	191
Period of one complete orbit	1 hr, 49 min, 20 sec	1 hr, 53 min, 7 sec
Minimum duration of a *Sputnik* day	58 min, 24 sec	1 hr, 5 min, 5 sec
Relationship of duration of a *Sputnik* day to the period of a complete orbit (percent)	53.4	57.5
Maximum duration of a *Sputnik* night	50 min, 56 sec	48 min, 1 sec
Relation of duration of a *Sputnik* night to the period of a complete orbit (percent)	46.6	42.4
Minimum arc of orbit during which *Sputnik* in the shadow of moon	192°16′	207°10′
Maximum arc of orbit during which *Sputnik* in sunlight	167°44′	152°50′
Heavenly arc described by *Sputnik* as seen by an observer in the plane of orbit on the moon's surface	12°16′	27°10′
Length of spherical segment of moon visible from *Sputnik* (kilometers/miles)	372/231	824/512
Relationship of area of moon's visible spherical segment to surface of moon (percent)	0.286	1.398
Maximum duration of observation from a point on the moon	3 min, 42 sec	8 min, 32 sec
Acceleration of free fall in orbit (meters per sec^2/feet per sec^2)	1.60/5.25	1.53/5.02
Relationship of previous value above to the acceleration of free fall to the moon's surface (percent)	98.9	94.5
Minimum number of orbits required for complete coverage of the moon's surface	15	7
Angles between consecutive planes of orbit	12°1′	25°42′
Velocity required to change plane of orbit (meters per sec/feet per sec/miles per hour)	350/1,148/782	736/2,415/1,646
Total velocity required for accomplishing all changes of planes of orbits (meters per sec/feet per sec/miles per hr)	4,900/16,077/10,962	4,418/14,485/9,876
Minimum duration required for complete coverage of moon's surface	27 hrs, 20 min	14 hrs, 57 mins
Relationship of coverage of moon's surface to actual surface (percent)	160	169
Amount of excess velocity required to leave *Sputnik* for surface of moon (meters per sec/feet per sec/miles per hr)	3/9.8/5	12/39.4/27
Total velocity during descent from *Sputnik* to surface of moon (meters per sec/feet per sec/miles per hr)	1,683/5,525/3,765	1,703/5,587/3,810
Duration of descent from *Sputnik* to the surface of the moon	53 min, 30 sec	54 min, 31 sec

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[*] *Head, Foreign Language Division, U.S. Naval Intelligence School, Washington, D.C.*

Detection Seen Possible by Star Occlusion

ACF technician proposes to AAS meeting that telescope be mounted to a space platform and stabilized by slaving it to three reference stars.

WASHINGTON—A telescope mounted in a satellite or space station would be used for long-range detection in a method proposed by H. Dubner of Avion Division of ACF Industries in a paper presented at a recent meeting of the American Astronautical Society.

The proposed method, described in a paper titled "Long-Range Detection By Star Occlusion," is based on the fact that an object moving in space must eventually pass between an observer and some stars.

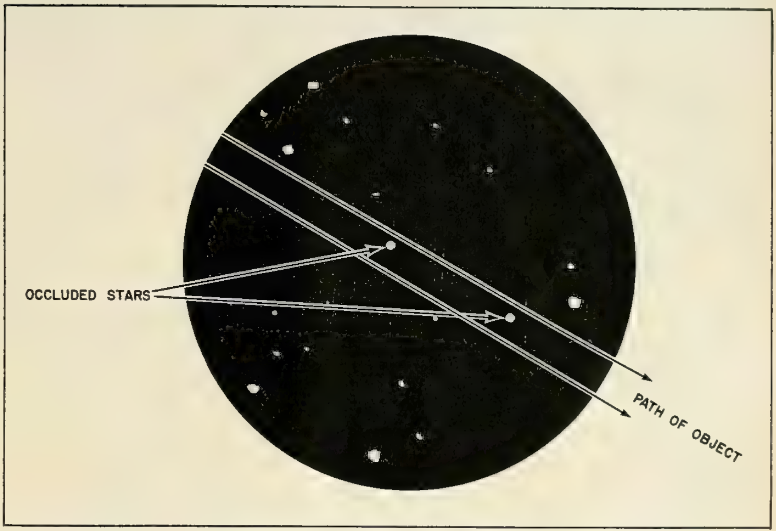
Dubner's method would use a telescope, a detector, a storage and comparator device, a clock and a computer. Since the computer would most likely be Earth-bound, a data link for telemetering would be necessary.

The telescope would be mounted on a space platform stabilized by slaving it to three reference stars. The view would be transferred from the telescope to a practical electrical outlet by an integrating image tube such as an image-intensifier orthicon. The output would then be stored for comparison with the following frame to determine occurrence and location of occlusions. Occlusion time and location then become an input to a computer which figures orbits and trajectories.

- **Stellar tripod**—For the telescope stabilization, the author proposes that a "stellar tripod" be used, with small telescopes focused on three reference stars as the tripod legs.

The telescope itself would be the 20-inch unit used by astronomers with a resolution of about 1/5-second. An f/1 concentric telescope is considered sufficient for desired resolution over large fields of view. The orthicon mentioned by Dubner is an RCA unit with a potential sensitivity six times as great as the human eye and a resolution of 100 lines/inch.

Using the case of a 10-foot object traveling at an orbiting velocity of



OBJECT MOVING in space eventually must pass between observer and star.

OCCLUSION TECHNIQUE ACCURACY

h = DISTANCE FROM EARTH	200 MI.	2,000 MI.
TIME FOR ONE REVOLUTION	91 MIN.	156 MIN.
MAXIMUM TIME ORBIT IS VISIBLE FROM EARTH'S SURFACE	9 MIN.	41 MIN.
TIME BETWEEN OCCLUSIONS	15 SEC.	26 SEC.
Δh DUE TO TIME ERROR OF .01 SEC. OF TIME	5.5 MI.	4.6 MI.
Δh DUE TO ANGULAR ERROR OF 1 SEC. OF ARC	2.33 MI.	3.33 MI.

ASSUMPTIONS:
1. CIRCULAR ORBIT AROUND EARTH
2. ONE STAR OCCLUDED PER DEGREE OF ARC

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20,000 feet/second, Dubner figures occlusion time as 1/2000-second. For optimum sensitivity, he says, frame time should be about equal to time of occlusion indicating that more than one detector would be necessary.

The graph shows an example of data for two targets at distances of 200 and 2000 miles above the surface of the Earth for the conditions of two occlusions separated by 1 degree. Input errors of 0.01 second of time and 1 second of arc have been assumed. Orbit errors can be reduced by additional occlusions and the knowledge that the target is following ballistic course could be used to improve system sensitivity.

False indications of occlusion may occur at low signal-to-noise ratios, but if this occlusion is stored and compared with future occlusions it could be evaluated for validity. Dubner has developed a method of determining whether the occlusion is a false alarm or not and gives a derivation in the paper.

•**Limitations**—According to Dubner, two major limitations exist. Both are concerned with light; i.e., the wave character of light imposes range limitations, and the granular character of light imposes velocity limitations.

The range is limited because an object passing in front of a star does not cast a true geometric shadow—it forms a diffraction pattern. The smaller the object or the greater the distance to the observer, the larger the diffraction pattern, until finally the object cannot be discerned as occluding a star.

The velocity limitation is more serious, according to Dubner. Light from a star travels in the form of photons and the ability to detect a star is determined by the presence of a certain number of photons per second striking the detecting device.

Assuming that 16,000 photons/second enter the telescope aperture for the dimmest detectable star, if an object occludes a star for about 1/16,000-second, it would be difficult to determine whether the star has been occluded. In such an interval the chances are about 37% that a photon would not have arrived.

The detector itself creates further difficulties since it will not necessarily respond to each photon.

Dubner illustrates this with the example that the efficiency of the eye to sunlight is about 1% which means, he says, that about 100 photons are required to obtain a response from the eye. The orthicon has an efficiency of about 6 per cent.

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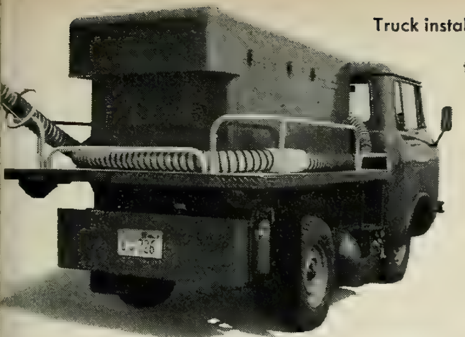

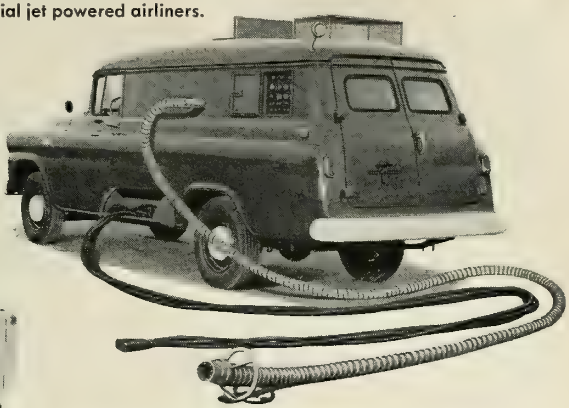

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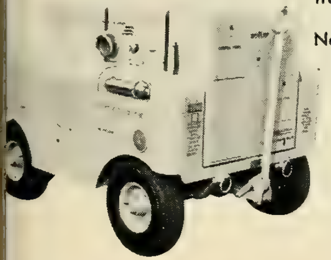
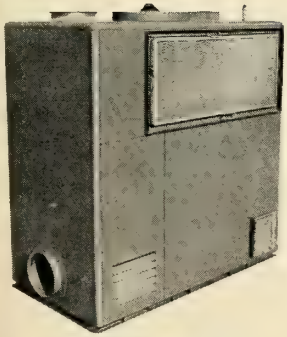


Air transportable pod for engine starting, cooling of electronic equipment and pre-flight checkout for military aircraft.



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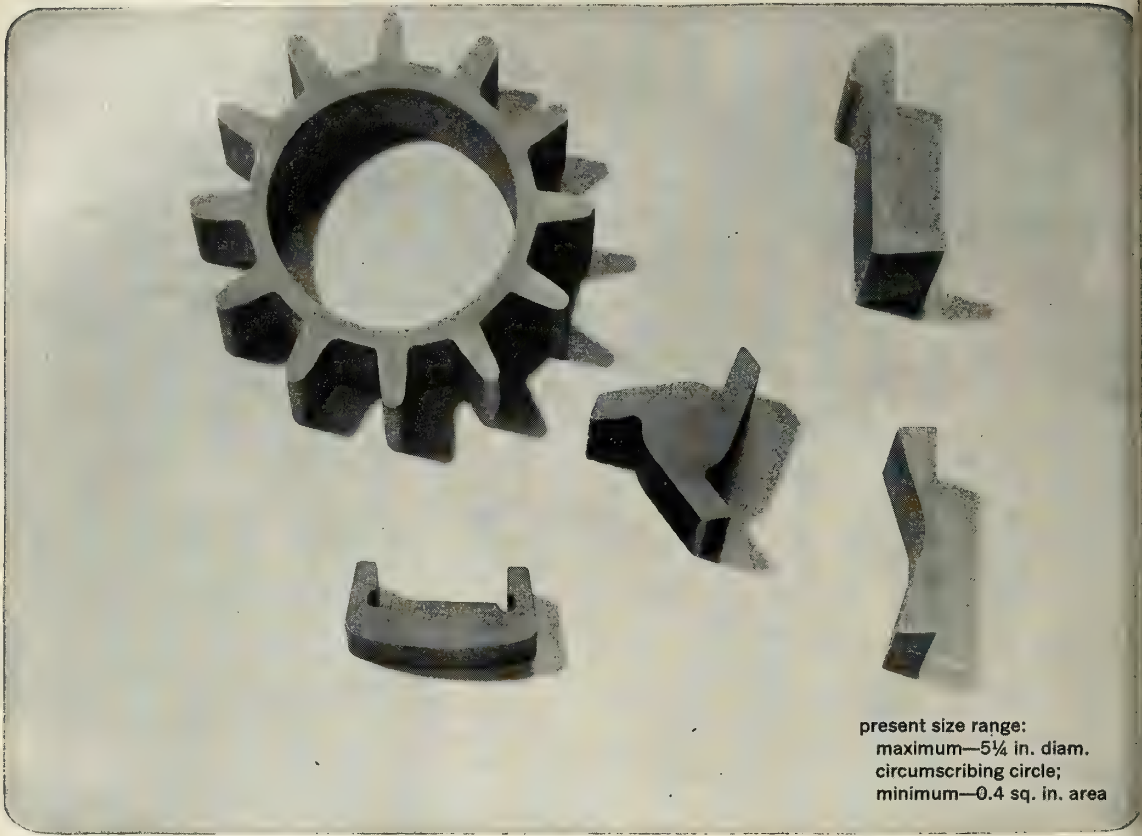

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Simplified Guidance Proposed

WASHINGTON—Two Sperry scientists believe that travel to the moon can be simplified by using a guidance system dealing strictly with Earth-vehicle and moon-vehicle problems on a two-dimensional basis.

The method, suggested by C. A. Brown and R. Fleisig of Sperry Gyroscope, was presented at a session of the American Astronautical Society during the convention of the American Association for the Advancement of Science.

In a paper titled "Simplified Space Guidance System Analysis," Brown and Fleisig discussed their procedure for estimating space guidance accuracy requirements and the results they had obtained.

Although the procedure would be useful for a wide range of space problems including interplanetary flight, the authors considered the moon as the objective in the specific applications presented.

•The problems—Two problems were considered: A vehicle launched from Earth and required to impact the moon; and a vehicle required to orbit the moon within prescribed altitude limits.

The method calls for a trajectory analysis to determine the sensitivity of guidance system parameters to variations in moon mission requirements and midcourse correction capability. For the impact vehicle, applications of auxiliary thrust at points between cutoff and the moon are made for trajectory corrections. The analysis seeks to determine the trade-off between guidance accuracy requirements and thrust requirements for corrections en route to and near the moon.

Brown and Fleisig assume that the three-body Earth-moon vehicle problem may, for present purposes, be simplified to Earth-vehicle and moon-vehicle problems. They make this assumption because only deviations from a nominal trajectory—rather than the specific trajectory itself—require great accuracy. Additionally, the three bodies are assumed to be coplanar, resulting in two-dimensional considerations throughout.

• Simplified guidance—The authors briefly describe the simplified guidance analysis procedure as follows: "Although the lunar trajectories are conic sections described by an ellipse or a hyperbola with the focus at the Earth center for the initial 215,000 miles of flight and a hyperbola with a focus at the moon center for the remaining portion, no trajectories are plotted and computations are made only for those points along the trajectory at which a switch in coordinate systems or a thrust correction occurs.

"The procedure for switching from earth to moon coordinates is simple as are procedures for incorporating corrective thrusts at midcourse positions. Using the methods described (in the main body of the paper), the total time required for an engineering aid to complete a single computation leading to cutoff velocity vector accuracies for the case of unpowered flight is approximately 10 hours."

The set of terminal conditions assumed by Brown and Fleisig are based on a dead center impact on the moon. Satisfactory error trajectories correspond to impact anywhere on the surface of the moon as indicated by two of the trajectories illustrated which just graze the moon's surface.

The authors also describe the means for reducing the amount of correction necessary and work out the means for a simplified analysis for the guidance necessary to hit or orbit the moon. Copies of the paper are available from the Sperry Gyroscope Company, Astronautics Section, Air Armament Division, Great Neck, N.Y.

1958 Electronic Sales Hits Record $7.7 Billion

WASHINGTON—The electronics industry, overlooked by the 1958 recession, ended the year with a new factory sales record of $7.7 billion—$100 million above the previous high in 1957.

Industry economists predict that the 1959 sales peak will reach $8.3 billion.

Major reason for the boom, according to the Electronics Industries Association, is the military change-over from aircraft to missiles, which require more extensive and subtle electronics systems.

In its year-end review, EIA says military electronic equipment sales passed the $4.1 billion mark and represent well over half the total dollar volume.

EIA predicts that the emphasis on missiles will add further to the electronic industry's sales to the military in 1959. Total military electronic expenditures in 1959 are expected to rise to $4.4 billion.

Industry passed the consumer market in 1958 as the second largest buyer of electronic products, EIA reports, topping $1.4 billion for the year. Computer and data processing equipment represented the largest single items on industry's purchasing list.

Industry sales in 1959, EIA predicts, should continue to rise and probably will reach $1.5 billion.

The long range picture for the electronics industry, according to EIA, shows unlimited growth, with new industrial segments such as nuclear instrumentation and telemetry added to the fast-growing family of electronic products.

Sperry Develops New Flotation Fluid

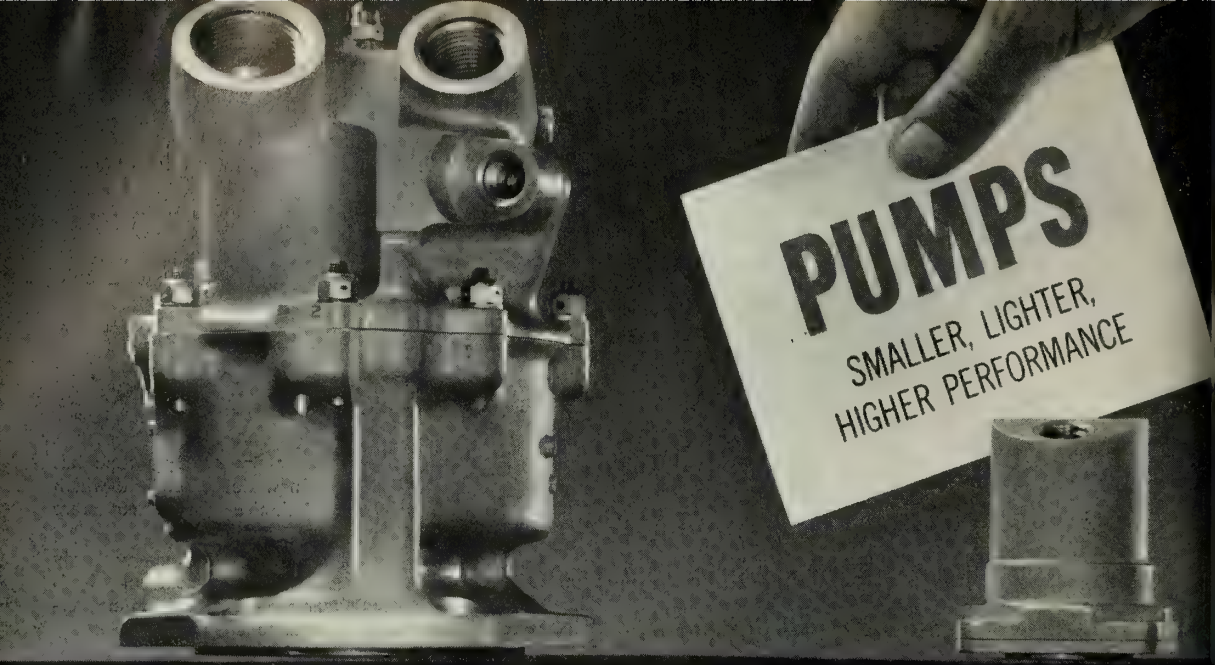
WASHINGTON—The Air Force has announced that Sperry Gyroscope has developed a new floatation fluid which might revolutionize the manufacture of fluid-floated gyros.

Company chemists, turning away from the chloro-fluorocarbon fluids generally used, devised a bromine version of the same class of compounds. The new fluid reportedly remains viscous to less than –65°F without artificial heating.

Because it remains viscous and never solidifies at low temperatures, it can be brought up to operating temperature very quickly without the damage hazard inherent in other floatation materials.

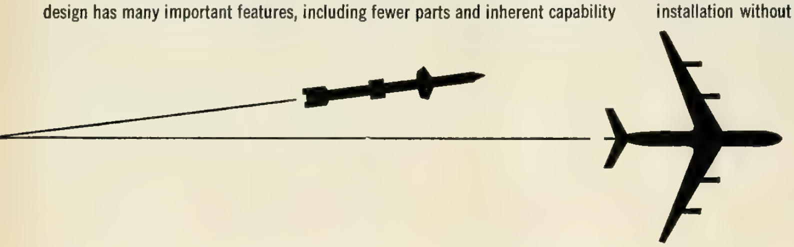
Conventional gyro fluids have always had the disadvantage of starting to solidify at temperatures not much below operating conditions. Hence, most fluid gyros are brought up to temperature in final test and kept that way throughout their service life. If the gyro heater fails in the sub-zero temperatures encountered in missile flight, the fluid can become so hard that it shatters into fine particles, damaging or occasionally severing the thin electrical leads that pass through it and

TESTING FLOTATION fluid.



AIRCRAFT AND MISSILE HYDRAULIC PUMPS

A new family of lightweight hydraulic pumps having fixed or variable displacement in sizes from 1 to 30 GPM operating at speeds up to 12,000 RPM and higher. This design has many important features, including fewer parts and inherent capability to perform at higher speeds and elevated operating temperatures. If you w send us your requirements we will be happy to submit recommendations for yo installation without obligation.



HOW BENDI

Bendix Hamilton was established in 1951 to develop and manufacture high precision fuel systems and hydraulic components for the aircraft industry. Today expanded facilities and a broader product line permit us to serve the missile industry as well.

Major products—aircraft and missile hydraulic pumps; hydraulic components and sub-systems; engine fuel pumps and fuel system components; precision bellows and bellows assemblies; thermostats and related sub-assemblies; and subcontract manufacturing and brazing.

PRECISION BELLOWS, SUB-ASSEMBLY WORK→

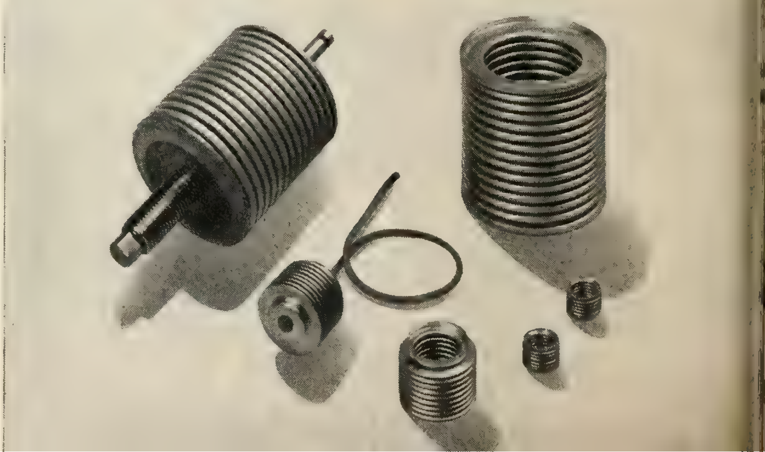
Bellows and bellows assemblies for aircraft and missiles, ordnance and other precision instrumentation tailored to your needs. Originally developed to meet the exacting requirements of aircraft and missile components bearing the Bendix name. Hydraulic forming together with precision process laboratory control of materials selected—brass, Phosphor bronze, beryllium copper, stainless steel, Monel, etc.—assure maximum resiliency and long service life.

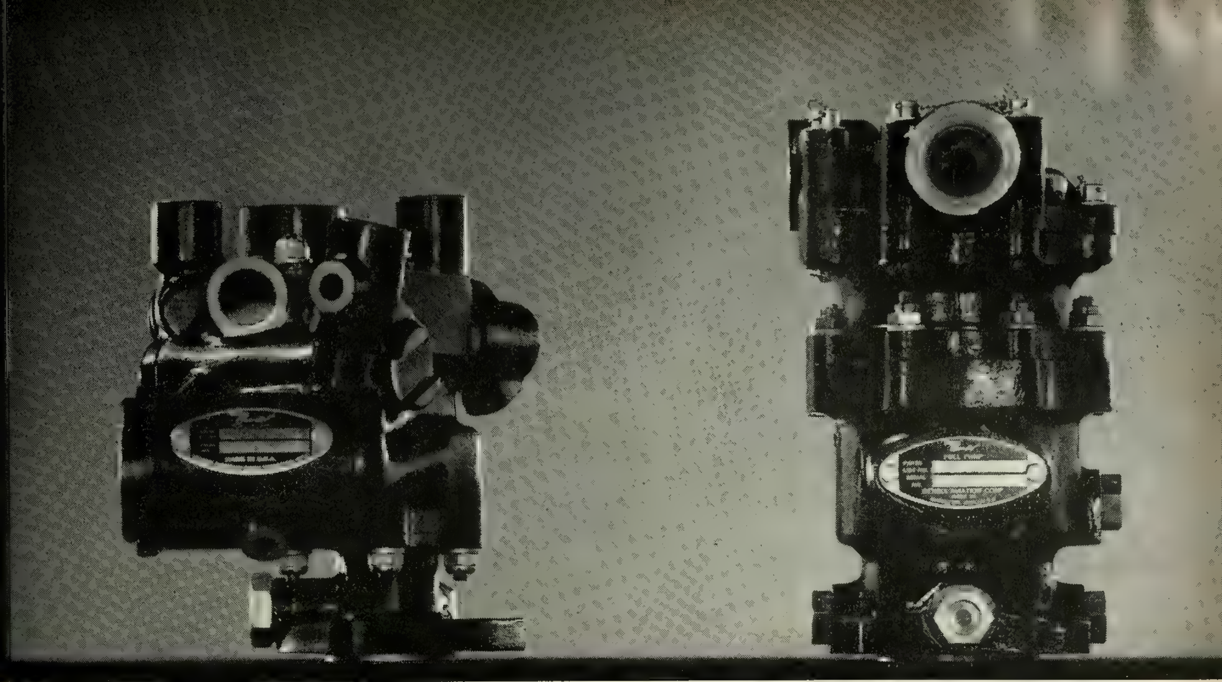
ALUMINUM DIP BRAZING

Molten flux dip brazing techniques offer freedom of design. Wrought,
stamped and pre-machined aluminu
alloy parts may be joined into comp
cated forms to provide lightweig
pressure-tight assemblies to repla
castings with complicated coring a
machining.

FURNACE BRAZING

Dry hydrogen brazing of high-strengt
high-temperature alloys using co
trolled atmosphere dry hydrogen fu
naces makes possible the fabrication

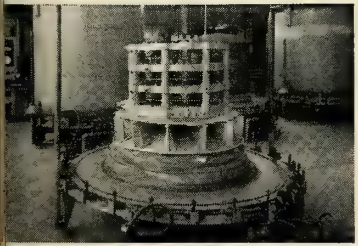




HYDROCARBON AND CHEMICAL FUEL PUMPS

new family of gear pumps for turbine engines and other applications for hydro- bon fuels in sizes from 150 pounds per hour to 3,000 pounds per hour at discharge essures up to 1,000 PSI. Piston fuel pumps are available for higher discharge pressures where required. A special mono-propellant pump having capacity from ½ to 4½ GPM at 3,600 RPM is also available for Ethylene Oxide, Hydrazine, Normal Propyl Nitrate, and other similar fuels.

AMILTON CAN HELP YOU



mplex assemblies such as turbine rner rings, manifolds, etc., up to ″ in diameter.

UB-CONTRACT ANUFACTURING

ailable sub-contract manufacturing ilities embrace all phases of produc- n engineering and precision machining, high-temperature brazing, assembly and test of customer-designed components and systems. Current aircraft engine and missile production programs include fuel and hydraulic components as well as surface control actuators.

SERVICE AND OVERHAUL

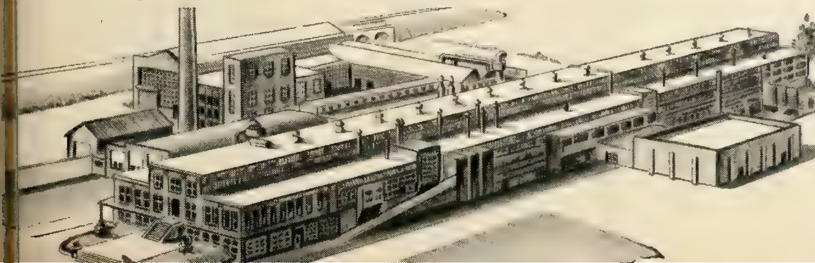
Complete field service and overhaul facilities are provided and offered to all customers in support of all original equipment programs—another reason why it will pay you to do business with Bendix Hamilton.

FACILITIES

Bendix Hamilton engineering, manufacturing and test facilities are diversified and complete to support all product programs. Physical plant space of 232,000 square feet includes air conditioned, humidity-controlled, dust-free areas for assembly and test of precision products.

Lapping operations hold flat surfaces within one light band when checked with an optical flat. Grinding and honing departments continuously maintain tolerances as low as five millionths of an inch on production work.

The specialized engineering and production test facilities offered to any Bendix Hamilton customer are complete to develop and produce equipment to the most exacting requirements of the aircraft and missile industries. They assure a quality end item manufactured and tested to your specifications.



Hamilton Division
HAMILTON, OHIO

Bendix
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RAYTHEON-DESIGNED Hawk missile annihilates radio-controlled F-80 jet fighter at 500 ft. altitude.

ARMY'S HAWK MISSILE is fired from mobile launcher. Missiles, launcher and support equipment can be air-lifted or quickly transported by Army or Marine ground forces.

NEW ARMY MISSILE DESTROYS LOW-FLYING AIRCRAFT

This *proven* anti-aircraft missile operates even at tree-top heights, in the blind zone of other radar-controlled missiles.

Raytheon is prime contractor for the U.S. Army Hawk weapon system—now in production and slated for use with fast-moving Army and Marine Corps ground forces as well as for the defense of U. S. cities.

RAYTHEON

Excellence in Electronics

RAYTHEON MANUFACTURING COMPANY, Waltham, Mass.

conduct power to the gyro wheel.

Sperry chemists say the new fluid maintains its plasticity at less than –65°F without artificial heating. Viscosities and densities can be easily adjusted to meet a wide variety of gyro operating requirements.

Although the fluid was developed in connection with Sperry's B-58 Hustler bombing-navigation system, future uses will probably center around missile and space vehicle navigation systems. Freedom from the requirement for continuous heat on gyros and gyro accelerometers will be a considerable aid to inertial system designers.

GE Uses 'Woofers' To Test Components

PHILADELPHIA—The world's most powerful hi-fi woofers (speakers) are being used by the missile industry to test components.

Highly intense noise, provided by random noise generators and amplified to an ear-splitting 145 decibels by three 600-watt loudspeakers, is used by General Electric's Missile and Space Vehicle Department to test missile and space vehicle components.

Extreme vibrations set up by these noise levels approximate those produced by rocket and jet engines. To insure components against failure caused by noise vibration, aircraft and missile manufacturers can use such noise devices for preliminary tests in the laboratory.

At GE's Missile and Space Vehicle Department, three 600-watt loudspeakers blare into a 120-cubic foot chamber, whose seven walls are out of parallel alignment.

General Electric has used this facility to test the nose cone electronic components—amplifiers, recorders, and other noise-sensitive devices—before they are installed in the nose cones for *Atlas* and *Thor* missiles which the company is developing for the Air Force. By allowing the noise to flow into a 3150-cubic foot room, a complete nose cone can be tested.

Temco Develops TV Surveillance System

DALLAS—An airborne television surveillance system has been developed by Temco Aircraft under contract from the Navy, which is now evaluating it at Patuxent River Naval Air Station, Maryland.

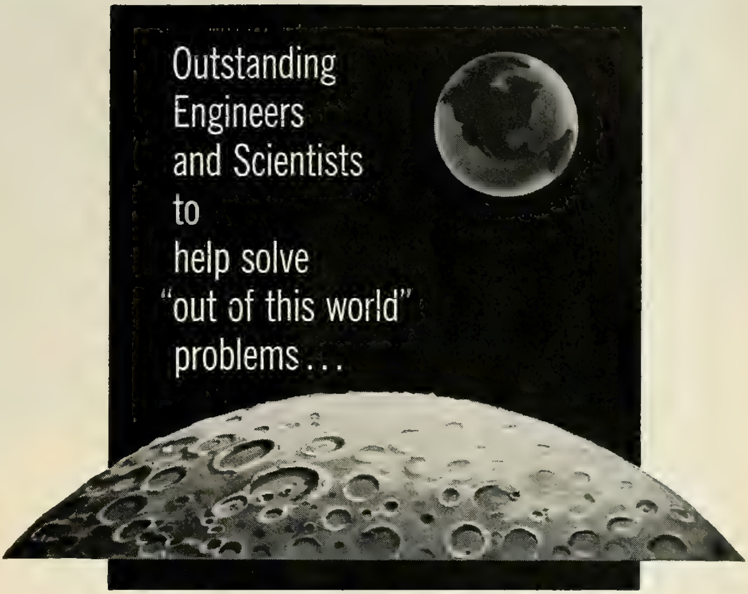
Although the system, called "Alpha," was originally designed as a means of missile terminal guidance, the present evaluation is also considering reconnaissance work.

Aerodynamically, test models of the Alpha resemble a small missile in shape, 8¼ inches in diameter and 105 inches long. In terminal guidance, the Alpha returns an image of the terrain to a central control station. As the weapon using Alpha closes on the target, the course is guided by radio signals transmitted by an operator watching a television receiver in the master control station many miles away.

This system might be planned for use in the newest version of the Navy's *Bullpup*, which will use a packaged liquid-fuel engine, a nuclear warhead, and an "improved" guidance system. The USAF reportedly will use similar features on its upcoming *White Lance*.

During the evaluation, television information relayed by Alpha is being fed into a video tape recorder manufactured by the Minnesota Mining and Manufacturing Co. The recorder permits immediate review of television information recorded during flight, eliminating time lost for film development.

As a reconnaissance system, the in-



Today artificial satellites orbit in space. Missiles can span continents. Conservative scientists calmly talk of landing on the moon.

Just as they have contributed to other aeronautical sciences, the various divisions of United Aircraft Corporation have made significant contributions to these new fields of missiles and space technology.

Recently the outstanding scientists and engineers who had specialized in missiles, missile guidance and space penetration problems in each division were brought together to focus their combined skills on advanced concepts and systems. A new Division was created . . . the Missiles & Space Systems Division.

This division is only weeks old. It is in an explosive growth period. Yet it has a built-in stability factor . . . the advantages of the brainpower, the "know-how", the financial resources and the unique facilities of a billion-dollar corporation that is already preeminent in aeronautics.

This combination of newness and stability should be significant to every alert engineer or scientist. It should suggest a unique opportunity to demonstrate ability and win the advancement and other rewards that ability deserves.

If you are looking for opportunity, we suggest that you contact us immediately.

Positions are available at all levels in . . .

ELECTRONICS: Guidance, Radar, Countermeasures, Computers, Telemetry • SYSTEMS ANALYSIS • SYSTEMS INTEGRATION • MILITARY REQUIREMENTS • RELIABILITY • GROUND SUPPORT • SPACE TECHNOLOGY: Astrophysics, Astronautics • AERONAUTICS: Preliminary Design, Performance, Aerodynamics, Structures, Propulsion.

Please send your complete resume, including salary requirements, to Mr. John B. North.

MISSILES & SPACE SYSTEMS

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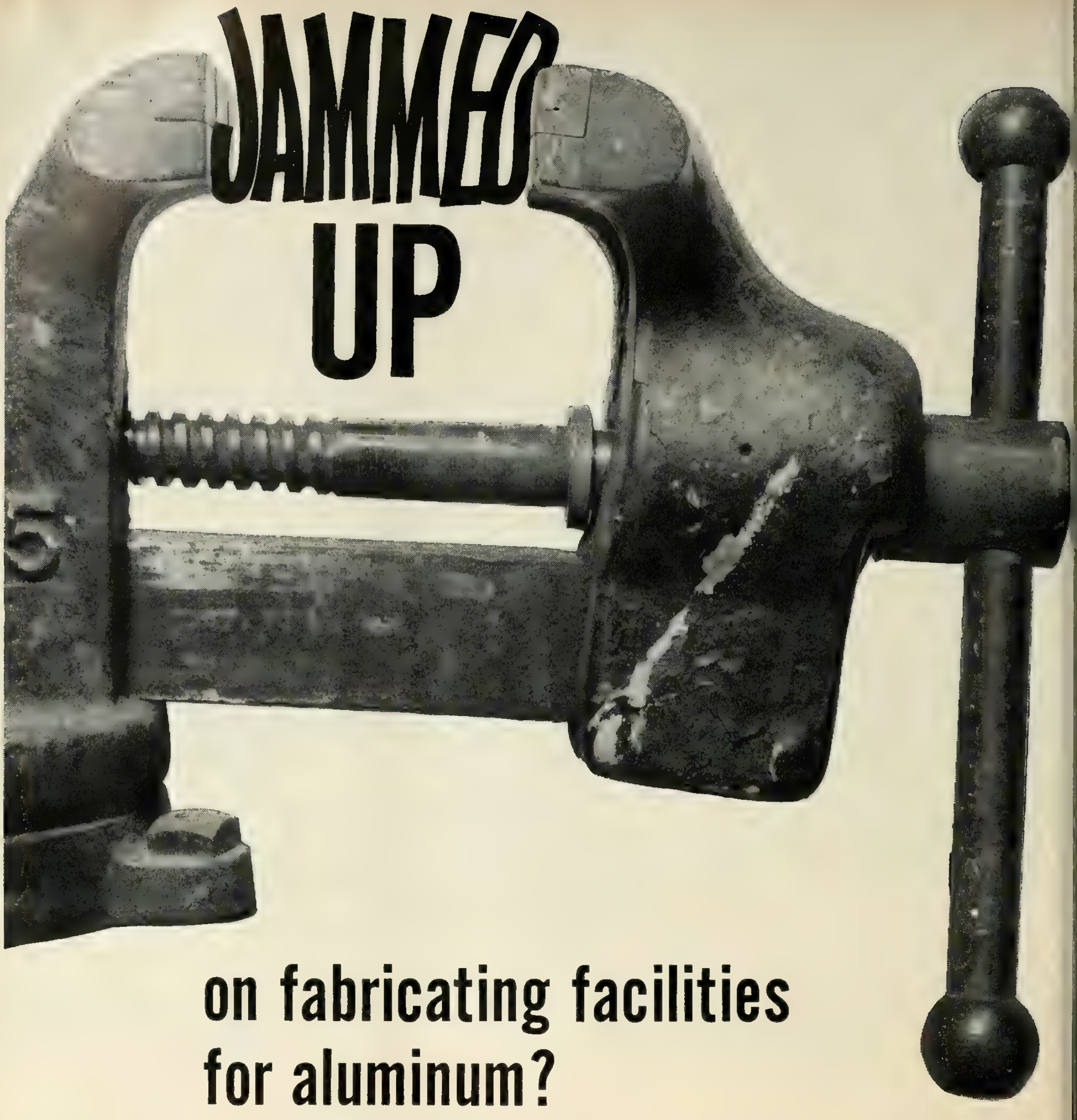

on fabricating facilities for aluminum?

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WANT TO stretch your aluminum fabricating facilities, particularly during peak production periods?

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COST . . . ? Frequently *less* than your own cost-accountants would report for a do-it-yourself job. For Alcoa *already* has the major facilities for production—plus the facilities and skills for tooling-up at rock-bottom costs.

WANT TO know more . . . ? Write Aluminum Company of America, 2029-A Alcoa Building, Pittsburgh 19, Pa., for 16-page booklet on the available facilities of Alcoa's Jobbing Division. Facilities at *your* service . . . for welding, rolling, brake-forming, bending, spinning, finishing, testing and other services. You'll be surprised how much Alcoa can help you *lighten* your load!

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ALUMINUM
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formation pictured by the TV conceivably could be recorded on the video tape recorder and triggered for transmission to earth when the satellite or vehicle was in a favorable transmitting area.

New Space Testing Lab. Opened at Newton, Mass.

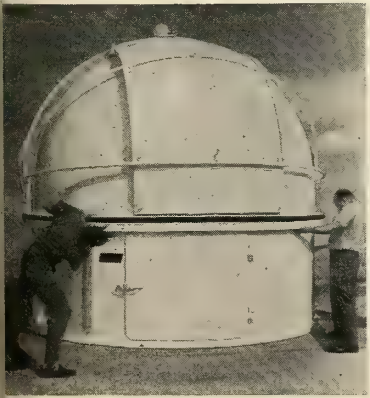
NEWTON, MASS.—NRC Equipment Corp., a subsidiary of the National Research Corp., has formed a new engineering and sales groups to handle its space testing facilities.

Vice-president and general manager James H. Moore said the new departments will assume all-over responsibility for ultra-high altitude test chambers, vacuum pumps, vacuum instrumentation and related accessories, and environmental facilities for testing men, materials and products in space.

Moore said that most of NRC's present facilities are limited to simulating altitudes below 100,000 feet, but that more sophisticated equipment would be designed for higher altitudes "as we learn more about outer space."

NRC already has some non-classified equipment which simulates higher altitudes, including a number of chambers which test components under pressures and temperatures up to 300,000 feet, and some smaller facilities for creating pressures equivalent to altitudes approaching 400 miles.

Fiberglass Astrodomes



WEATHERPROOF ASTRODOMES are being used to protect instrumentation, motion picture cameras, telescopes and other equipment used in tracking missiles. Manufactured by the Houston Fearless Corp., the astrodomes are made of impregnated honeycomb covered with fiber glass.

For the rocket and missile speed up programs ahead...

Lebanon Steel's Special Products Division offers cast steel component parts from 3 ounces to 300 pounds . . .

cast precisely to drawing in high or super alloy steels of class I x-ray quality
Nozzle ring for rocket engine, cast for Reaction Motors in stainless steel.
12"

. . . precision quality at significant TIME & COST SAVINGS

THIS CAST NOZZLE RING for a rocket engine illustrates how Lebanon Steel Foundry can become indispensable to your missile or rocket program. Here Lebanon's unique experience and facilities enabled production of a vital component to proceed from *drawing* to *finished part* at minimum time and at great savings in tooling and production costs.

This casting achieves all the advantages of precision methods. Tolerance control demands absolute accuracy of core placement and smooth metal surfaces cast precisely to drawing in order to reproduce the curved contours of the internal passages, which would be virtually impossible to machine. Cast holes are round on one side, rectangular on the other.

This casting was produced by Lebanon's CERAMICAST ® Process. *No other known method offers production of such an intricate stainless steel component at anything approaching Lebanon's time and cost factors.*

This experience is available to you *now.* To take the fullest advantage of the assistance we can render in your rocket and missile prototype work, consult us at the earliest stage of your design project.

Special facilities have been created at Lebanon to get all available foundry engineering help to you *when you want it.* For immediate action on your inquiry, phone or write DEPARTMENT AM.

**Produced under licensing agreement with Shaw Processes, Ltd.*

CIRCLE L
STEEL CASTINGS for the SPACE AGE

LEBANON STEEL FOUNDRY
AIRCRAFT AND MISSILES PRODUCTS SECTION
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CHRISTIE'S rigid Quality Control is approved by the A. E. C. and leading Aircraft and Missile Manufacturers.

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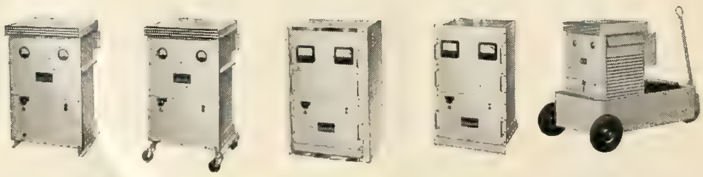
Precisely regulated Power Supplies of permanent stability. Ratings up to 1500 amperes. Bulletin on Standard Militarized units available on request.



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moscow briefs

The rise in U.S. rocket and missil production is noted in Krasnaya Zvezd official organ of the Soviet arme forces.

In his article, "Problems of Stru gle for Domination in the Air," Ma Gen. G. Pshenianik writes that whi in the 1953-54 fiscal year, America "expenditures for rocket weapons we $504 million, or about six % of th sum spent on the purchase of militar aircraft. In the 1957-58 fiscal year suc expenditures amount to more tha $2.5 billion or more than 35 % of th sum allotted for the purchase of mil tary aircraft."

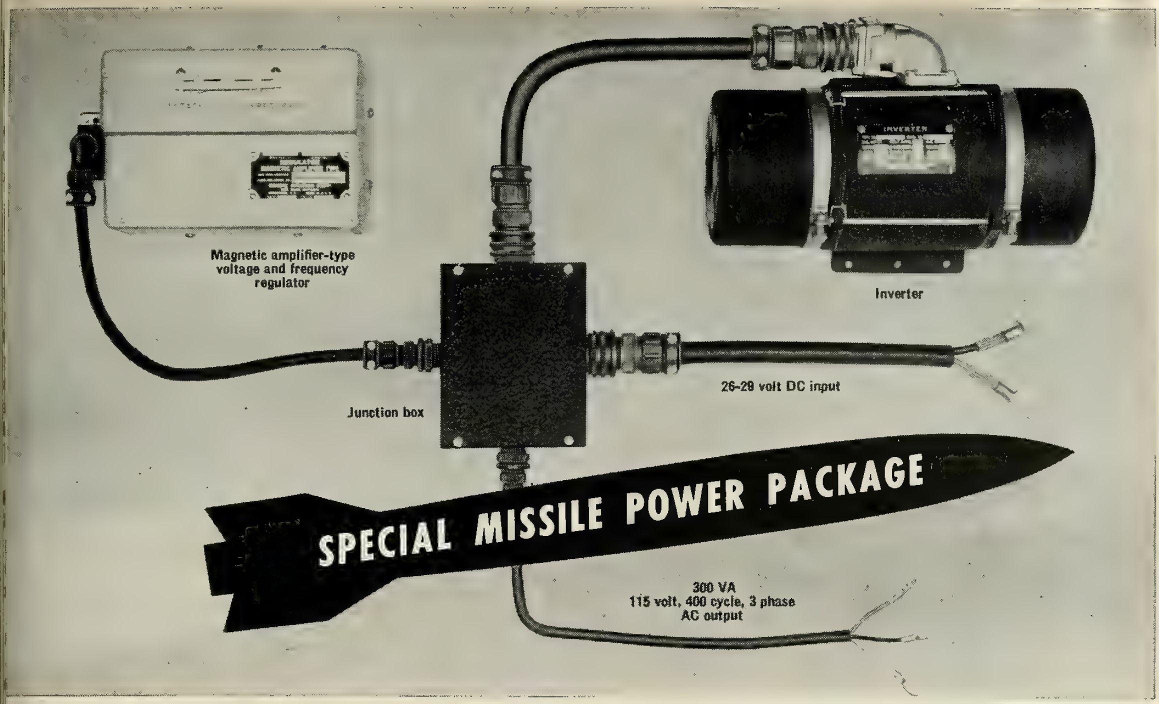
Gen. Pshenianik concludes: "Th leading military circles of the US continue to place their main trust i the forces of military aviation, partic larly in strategic aircraft and rock weapons."

The author of this article is n only an air force general but also scientist with the degree of candida of the military sciences.

Commenting on current reorganiz tion of U.S. armed forces, Lt. Col. Y Makhov writes in Sovetskaya Aviats that "out of the eight newly confirme American commanders, four are a force generals, three are admirals, an only one is an army general." Makhov article, entitled "The Structure is Ne but the Policy is the Same," stress the importance of "strategic aviatio this chief weapon of threats and blac mail in the hands of American in perialists."

How can man hold an artifici satellite at a necessary height a long time than he can now? In Znanie—Sil author M. Astrov answers: "Very sin ply—by supplying the satellites wi means of motion. Since the resistan of the atmosphere at 100-200 kilom ters above the Earth's surface . . . very small, the motor force needed overcome this resistance will also quite small. Such motor-furnishe *Sputniki* will be 'sky auto-cars,' so say. To distinguish them from satellit let us call them satelloids."

The world's largest electromagn to study cosmic radiation is claimed the Soviets. The Moscow *Trud* repor the equipment is installed at the Ar gats High-Altitude Station of th Physics Institute of the Soviet A menian Academy of Sciences. Th newspaper adds that a still more po erful electromagnet for the same pu pose (and also for the work of A menian physicists) is being built


Magnetic amplifier-type voltage and frequency regulator
Inverter
Junction box
26-29 volt DC input
SPECIAL MISSILE POWER PACKAGE
300 VA
115 volt, 400 cycle, 3 phase
AC output

An example of the Bendix Red Bank complete line of high-altitude and missile inverters

As aircraft and missile performance continue to step up, Bendix Red Bank designers continue to lead the field in developing new, high-performance inverters and power packages.

We now offer a complete line of inverters from 6 VA to 7,000 VA, including advanced special-application units and missile type power packages like the one shown above.

If we don't have an inverter to meet your specific needs, we'll design one. For full details, write RED BANK DIVISION, BENDIX AVIATION CORPORATION, EATONTOWN, NEW JERSEY.

West Coast Sales and Service: 117 E. Providencia Ave., Burbank, Calif.
Canadian Affiliate: Computing Devices of Canada, Ltd., P. O. Box 508, Ottawa 4, Ont.
Export Sales & Service: Bendix International, 205 E. 42nd St., New York 17, N. Y.

MISSILE INVERTERS—400 CYCLE OUTPUT
(Incorporate Static Type Controls)

Type	Input		Rated Output			Max. Altitude at Rated Output	Approx. Wt. Lbs.	Designed to Gov't. Part No.
	Volts	Amps.	Volts	Phase	VA Rating			
32B92	27.5	126	115	1 3	1500 1800	20,000	37	—
32B81	27.5	100	115/200	3	1500	Unlimited	65	—
32B77	27.5	180	115/200	3	3000	Unlimited	75	—
32B79	27.5	400	115/200	3	7000	Unlimited	115	—
32B76	27.5	20	115	3	500	70,000	25	—
32B122	27.5	150	115/200	3	2500	50,000	65	—
32B41	27.5	150	115/200	1 3	2500 3000	50,000	68	—
32B52	27.5	35	115/200	1 3	500 500	40,000	25	—
32B106	27.5	95	115	3	1400	35,000	44	—
32B27	27.5	285	115/200	1 3	3500 4000	50,000	76	—

GENERAL PURPOSE INVERTERS—400 CYCLE OUTPUT

Type	Input		Rated Output			Max. Altitude at Rated Output	Approx. Wt. Lbs.	Designed to Gov't. Part No.
	Volts	Amps.	Volts	Phase	VA Rating			
12128	27.5	1	26	1	6	35,000	2.2	AN3496
12126	27.5	2	26	3	10	35,000	2.3	E1615
MG-54	27.5	22	115/200	1 3	250 250	50,000	17	E5109
12142	27.5	22	115	1 3	250 250	35,000	13	E1617
12143	27.5	22	115	3	250	35,000	13	—
32E01	27.5	35	115	3	500	50,000	26	AN3533-1
32E00	27.5	51	115	1 3	500 750	50,000	34	AN3534-1
MG-65	27.5	52	115/200	1 3	750 750	50,000	35	E52805-2
MG-61	27.5	126	115	1	1750	50,000	54	53C6767
1518	27.5	126	115	1 3	1500 1800	20,000	37	—
32E06	27.5	160	115/200	1 3	2000 2250	50,000	56	E1725
32E03-3	27.5	150	115	1	2500	50,000	58	53B6227
32E03-9	27.5	160	115/200	1 3	2500 3000	50,000	58	E54807
32E09	27.5	160	115	1 3	2500 3000	50,000	60	—

Red Bank Division Bendix AVIATION CORPORATION

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OCEAN

The Atlantic Ocean is the year-round playground of Pan Am engineers. The 5000-mile Atlantic Missile Range, for which we have the prime responsibility of management, operation and maintenance, extends from Cape Canaveral in Florida through the Bahamas to Ascension Island and beyond.

Our engineers in these locations water-ski, skin-dive, fish, sail, swim and live on the ocean and under the sun every day of the year. They work in the new and vital arts of missile range management, operation, maintenance and test data collection and reduction.

Qualified physicists, mathematicians and electronics engineers should investigate a future by the ocean with Pan Am. Please address a confidential resume to Mr. C. R. Borders, Assistant Division Technical Manager, Pan American World Airways, Inc., Patrick Air Force Base, Cocoa, Florida, Dept. B-2.

PAN AM
GUIDED MISSILES RANGE DIVISION
PATRICK AIR FORCE BASE, FLORIDA

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New!
TRANSISTORIZED
The A. W. HAYDON COMPANY'S
TRANSISTORIZED SUB-MINIATURE ELECTRONIC TIME DELAY RELAYS!

MINIATURE ELECTRONIC TIME DELAY RELAYS 31200 SERIES
SUB-MINIATURE ELECTRONIC TIME DELAY RELAYS 31300 SERIES

SAVE SPACE AND WEIGHT!

	Miniature Series	Sub-Miniature Series
Cross Section	1 7/16" x 1 21/32"	31/32" x 1 3/16"
Length	2 1/4" long	2" long
Weight	6 ounces	3 ounces
WRITE FOR:	Bulletin AWH TD-503	Bulletin AWH TD-504

TEST-PROVED PERFORMANCE!
High Temperature: 125°C (250°F).
Vibration: 2000 CPS at 15 g.
Contact arrangements up to 4 pole double throw.
Unique transistorized R.C. time constant network.
Time Delays from 50 MS to 120 seconds. Longer Delays available.
Hermetically sealed housings.

MEET REQUIREMENTS OF MIL-E-5272A.

AWH
The A.W. HAYDON Company
231 NORTH ELM STREET, WATERBURY 20, CONNECTICUT
® Design and Manufacture of Electro-Mechanical Timing Devices

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Leningrad. This machine will be installed in the little town of Nor Anberd in the Ashtarak Region of Armenia, 2,000 meters above sea level.

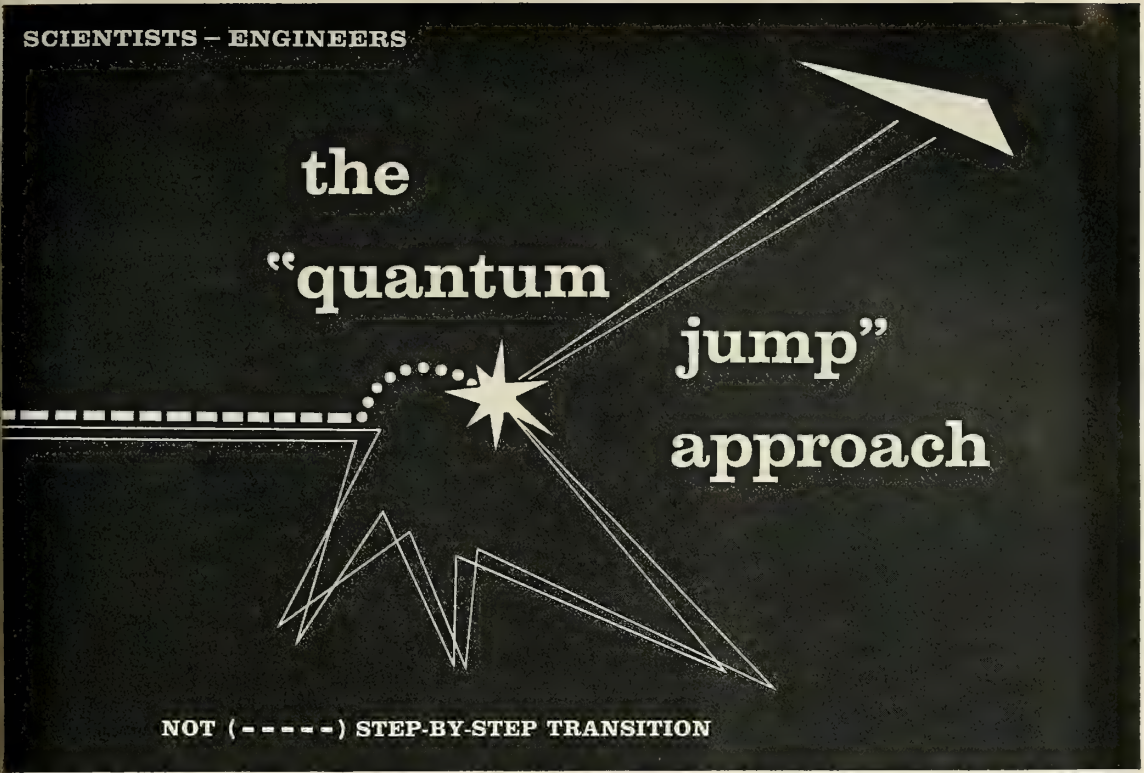
A system of automatic functioning for a large modern telescope has been worked out by a group of Soviet scientists at the Institute of Electromechanics of the Academy of Sciences. Yu. Sabinin, a candidate of the technical sciences, was in charge of the project. The system, installed at the Crimean Astrophysical Observatory, allows an observatory to leave its telescopes unattended, yet obtain photographs and other records of satellites, stars, comets or other celestial phenomena.

The easternmost *Sputnik*-**tracking station** in the Soviet Union is on the island of Sakhalin. The Soviet news agency TASS reports that the station is functioning at Yuzhno-Sakhalinsk, in the island's southern part, and is attached to the department of physics at the local teachers' college.

Conquest of outer space was the special theme of the celebration of the 41st anniversary of the Communist seizure of power in Russia. Soviet "cosmic decorations" dominated Moscow displays of the holiday. Full-sized models of the three *Sputniki* were hoisted over Gorky Street, the Red capital's main thoroughfare. The multitudes marching past Premier Khrushchev and his cronies on the Red Squar reviewing parapets, carried posters banners, and other exhibits showin Soviet rockets, missiles, and *Sputnik*

Khrushchev showed his deligh when the model of a space ship of th future, a gas-filled balloon dubbed th "Moon Rocket," was brought into th square by Soviet athletes dressed i star-spangled cloaks. When the "Moo Rocket" was released to float above th Lenin-Stalin mausoleum, Khrushche standing on the mausoleum's roof, wa seen to follow the balloon's flight wit great animation.

The first Polish rocket is report by *Sovetskaya Aviatsia*. It was ma and recently launched in the Blend Desert in Poland by the Craco branch of the Polish Astronautic S ciety, in collaboration with the Rock Section of the Ore and Metallur Academy in Cracow. The aim of t rocket launching was "meteorologic and other researchers in the upp strate of the atmosphere." The rock is described as 820 mm. long and mm. in diameter.



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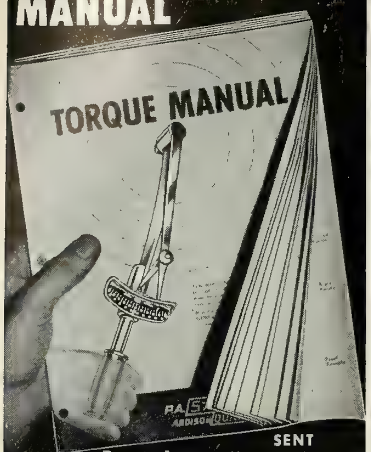

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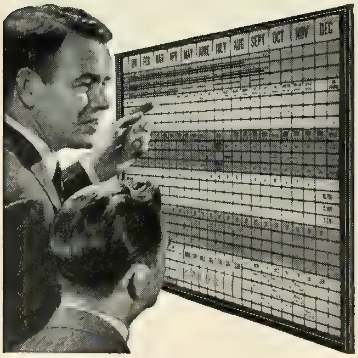

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soviet affairs

by Dr. Albert Parry

A few weeks before the launching of the *Atlas* satellite, Soviet astrophysicist Prof. V. V. Dobronravov recalled that following *Sputnik I* some American scientists said their country's "much-touted technology" could catch up with Soviet technology in two or three years. Others said it might take 10 years. Wrote the Russian savant in *Komsomolskaya Pravda*:

"Far be it from us to deprecate the potentialities of American science and technology and the knowledge and experience of American scientists and engineers (who, at that, readily avail themselves of the help given them by specialists of non-American origin). But the results of the year which has just passed show that the lag not only has not diminished but, on the contrary, has grown wider. With each day it is more and more difficult for Americans to catch up with us."

As the year approached its close, Soviet boasts continued. In the official newspaper of the Soviet armed forces *Krasnaya Zvezda,* Col. I. Verov reported that whereas in the 103 years from 1814 to 1917 only 36,078 inventions were patented in tsarist Russia, in just one year of 1957 more than 2 million inventions and technical improvements were recorded in the Soviet Union.

Occasionally, however, the Soviets do admit slowness in some fields of space-age engineering. In the computer realm, for instance, things are not as they should be. It is true that from 1950 to 1957 Soviet production of computing machines increased 17.6 times, and computer experts in that country are now being trained at the rate of several hundred annually. A new institute of mathematics, with a computing center, is being organized at Sverdlovsk in the Urals. But Russia's rocket and missile experts cry, "Not enough!"

In London recently, visiting Soviet Prof. A. P. Yershov, head of the theoretical programming department of the computer center of the Academy of Sciences, revealed that his staff lacks a system which would enable it to feed problems into computers without stopping to code them. Western mathematicians have a similar need, but the Russians may be worse off. Besides their usual Greek symbols, they sometimes complicate matters by trying their own Cyrillic as well as a synthetic language rigged up by computer specialists.

Expansion or computer-making and other electronic manufacture is now noted in other Red countries. Red China reports it is producing computers and other machines including "telescopes which register the intensity of cosmic radiation" and "various counters used to ascertain types, energies, and power of different radiations." With Kremlin permission, Poles are building their first small rockets with electronic ingredients. And East Germans are being entrusted with production of electronic components for Russia's *Sputniki.*

Strong winds on Mars are raising clouds of dust and sand, states Prof. V. Sharonov, in charge of the astronomical observatory at the University of Leningrad. He calls this phenomenon "an important event" and explains it by the influence of sun spots "upon Mars no less than upon our planet."

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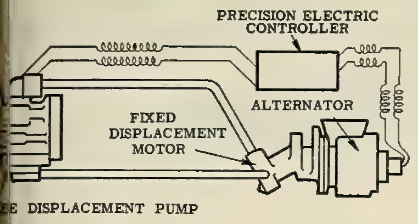

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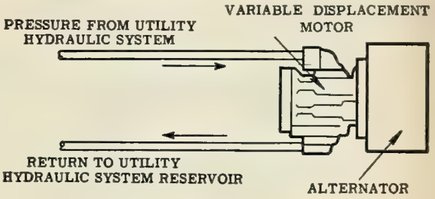
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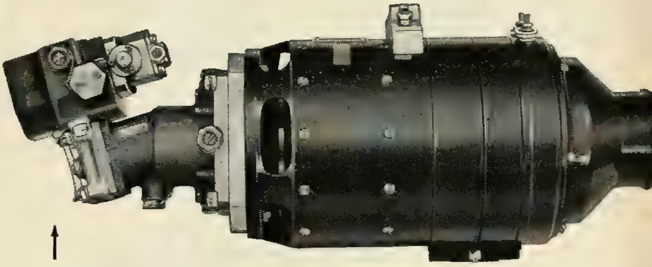

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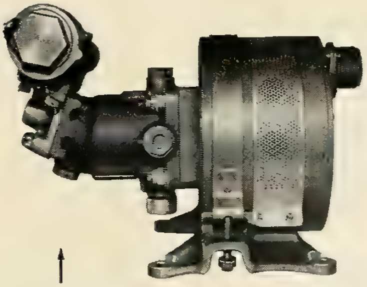

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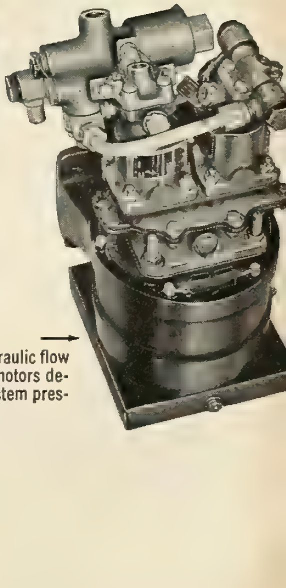

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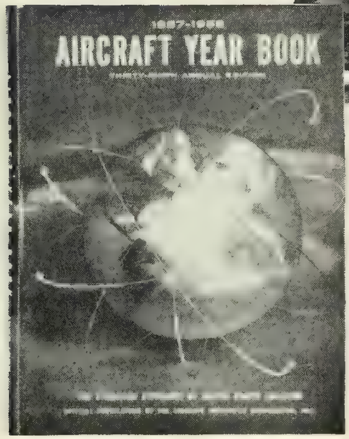

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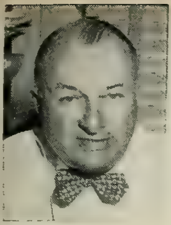

west coast industry

by Fred S. Hunter

The chips keep getting bigger all the time in the weapons-systems game as it is being played these days. A Douglas engineer, asked how much his company may have spent in preparing the proposal it submitted in the competition for assembly and test of *Minuteman,* made this off-hand reply: "Oh, about half a million dollars." This seems an astronomical figure, but a lot of man-hours are involved in taking an idea from an original concept, creating the design, setting up the complete technical data on feasibility manufacture, test, quality assurance, reliability, maintenance, service and supply. It takes from eight to twelve weeks to put together a proposal on a big job. Moreover, you can't use second-rate talent in the preparation of proposals or you'll never win one. So figure $15,000 a year as the average salary scale and your estimate will be fairly close. We've heard that Boeing is using 200 engineers in working up its bid on *Dyna-Soar* while 300 were used on *Minuteman.* Add other costs, such as travel, communications and the printing of all the fancy material and it is easy to see how the cost of preparing a bid on a development contract may come to as much as the fee you'll get if you win it. Smaller companies, bidding on subsystems, have cost problems in the same ratio as the big producers. For example, it cost Daystrom Pacific around $12,000 to prepare a recent proposal for a black box about half the size of the telephone handset on your desk.

Lee Stockford, corporate industrial relations advisor to Lockheed Aircraft Corp., warns of an impending serious shortage of young executives in the 35-to-40 year age bracket. It will come in about 1966. Stockford uses simple arithmetic and birth rate statistics to reach his conclusions. More than 4,200,000 children were born in the U.S. in 1955, but only 2,200,000 in 1940. The latter crop will be reaching 35 in 1966. From then until about 1977 there's going to be a shortage of bright young men. Management will be smart to plan now to push their young executives along a little faster and establish a policy of retaining retired executives in consulting capacity, Stockford advises.

Two of the *Polaris* test projects at Lockheed Missile Systems Division have the delightfully descriptive names of *Pea Shooter* and *Sky Hook.* But the one we really like is *LUMF.* It sounds as though Bert Lahr were pronouncing it. It means, as you might easily deduce, Lockheed Underwater Missile Test Facility. It's a tank for launching tests of scale models of the *Polaris.* The tank is 24 feet deep, which may or may not be a hint of the depth from which *Polaris* missiles are to be launched; the launching cradle is powered to move across the tank to simulate the forward speed of a submarine, and a "wave generator" (so named by the Navy) whips up waves to four feet high. Eight cameras, six under water, record all shots, although not all are trajectory tests. Lockheed averages four scale-model tests a day in the tank, or more in one day than in a week with full-scale models in the ocean.

The Navy is conducting classified studies of ocean currents and temperatures with an eye to use in antisubmarine warfare at its Ferndale Oceanography Station north of San Francisco. Newly developed electronic gear is said to furnish more accurate data than previously available. Long plagued by erratic sound wave transmission characteristics by underwater temperature "layers," the Navy is reported to be using much high-intensity sound generating equipment in the studies.

Howard L. Richardson, senior vice-president-Electronic Systems for Sylvania Electric Co., on a West Coast trip, indicated few changes will be noted in the company for some time after the merger with General Telephone Co., "but the merger will give us a chance to seek larger military orders than we have in the past."

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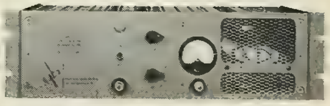

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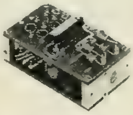

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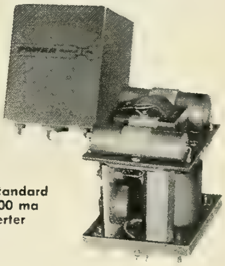

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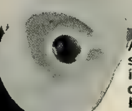

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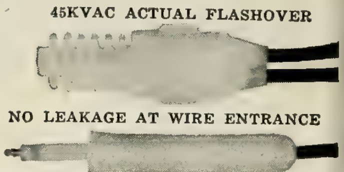

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book reviews

METALS FOR SUPERSONIC AIRCRAFT AND MISSILES, D. W. Grobecker (Ed.), American Society for Metals, 1958, Dept. A, 7301 Euclid Ave., Cleveland, 432 pp.

This is a compilation of technical papers presented at the Conference on Heat Tolerant Metals for Aerodynamic Applications held January 28-29, 1957 at the University of New Mexico.

It covers the entire field of aerodynamic and thermodynamic heating currently encountered by aircraft and missiles metallurgical studies involved in the high-temperature environment produced by the vehicles in flight.

Since the presentation of the papers was almost two years ago, some of the problem areas discussed by the authors probably do not exist at the present time. Still, the conference proceedings which were published this year emphasize many exacting environmental barriers that will have to be faced in the months and years to come and the need for intensive research in materials.

The papers presented generally conclude that:

1) The aerodynamic and thermodynamic problems cannot be solved by metals alone, even the rarer metals. The design limitation on material weight must be compromised as the needs for heat resistance increases.

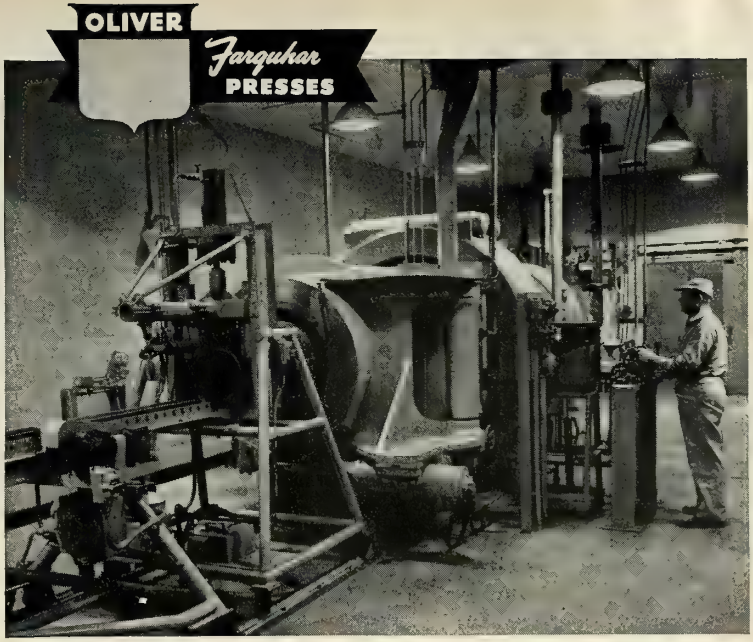
2) It will be necessary to insulate a high-strength internal structure with a high-heat resistance shell. Composite materials, consisting of coatings and laminations of metals and nonmetals must be employed.

3) Cermets offer great promise because of their strength, hardness, and heat resistance in addition to providing new ways to apply basic solid-state physics and chemistry to the production of new materials.

4) Materials research must be coordinated along with structural and aerodynamic development.

5) More basic research and development is needed within the metals ndustry including the broader field of solid-state physics, chemistry, ceramics, and surface chemistry.

Goal for achievement, the authors specifically concluded, should aim at providing the Air Force with those materials of which it has dire need, ncluding molybdenum alloys for withstanding increases in speed from Mach 3 to Mach 7 and rocket nozzle maerials with increased life at flame temperatures of 4000 to 5000 degrees F, which would increase range 400%.



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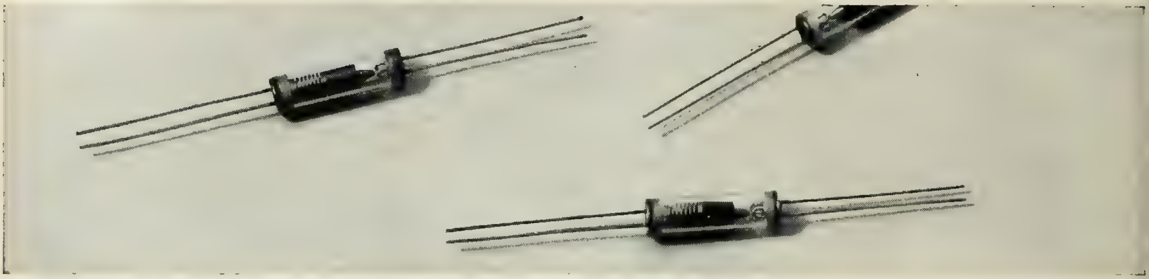

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Mars and Venus Probes

To the Editor:

As a regular reader of your fine magazine I was somewhat surprised by two statements made in your November 24 issue. I consider these statements to be erroneous.

One statement on page 13 indicates that a "minimum energy" Mars probe will occur around March 1, 1959. A "minimum energy" Mars probe can start around August, 1960 because such probes should start not 247 days ahead of a conjunction but 96 days ahead of an opposition. For Venus the favorable starting day is around June 1, 1959, 87 days ahead of an inferior conjunction rather than 151 days before a superior conjunction.

The other statement on page 28, says ". . . it would arrive in the vicinity of the moon at the conjunction and if it passed the moon it would proceed on into the sun instead of an orbit around it." This violates elementary laws of celestial mechanics. We will never shoot into the Sun, unless we are able to obtain a velocity change of over 70,000 mph., three times as much as the present moon-shots. In all other cases the rocket, if escaping the gravitational fields of the earth and the moon, will go into an orbit around the sun which may be more or less elliptic and have a period of more or less than a year. Shooting "straight into the sun" would tend to make the orbit time close to one year and the rocket would return into our vicinity after that time.

I realize that your publication has a drastic deadline problem which makes it difficult to check technical and scientific statements which are to appear. Yet I am sure that this must be done if the excellent standards which you have set are to be maintained—and upon which your readers depend.

Herman F. Michielsen
Research Specialist
Lockheed Aircraft Corp.

We stand corrected. A payload shot in the direction of the moon, when it is in conjunction, would not travel on to an impact with the sun if it missed the lunar body. Through the use of vector analysis it can be shown that an object fired directly at the sun with a maximum velocity of seven miles per second from the earth, which is traveling around the sun with a tangential velocity of about 18 miles per second, would travel in an elliptical orbit quite similar to earth's orbit with a maximum velocity about the sun of approximately 20 miles per second.

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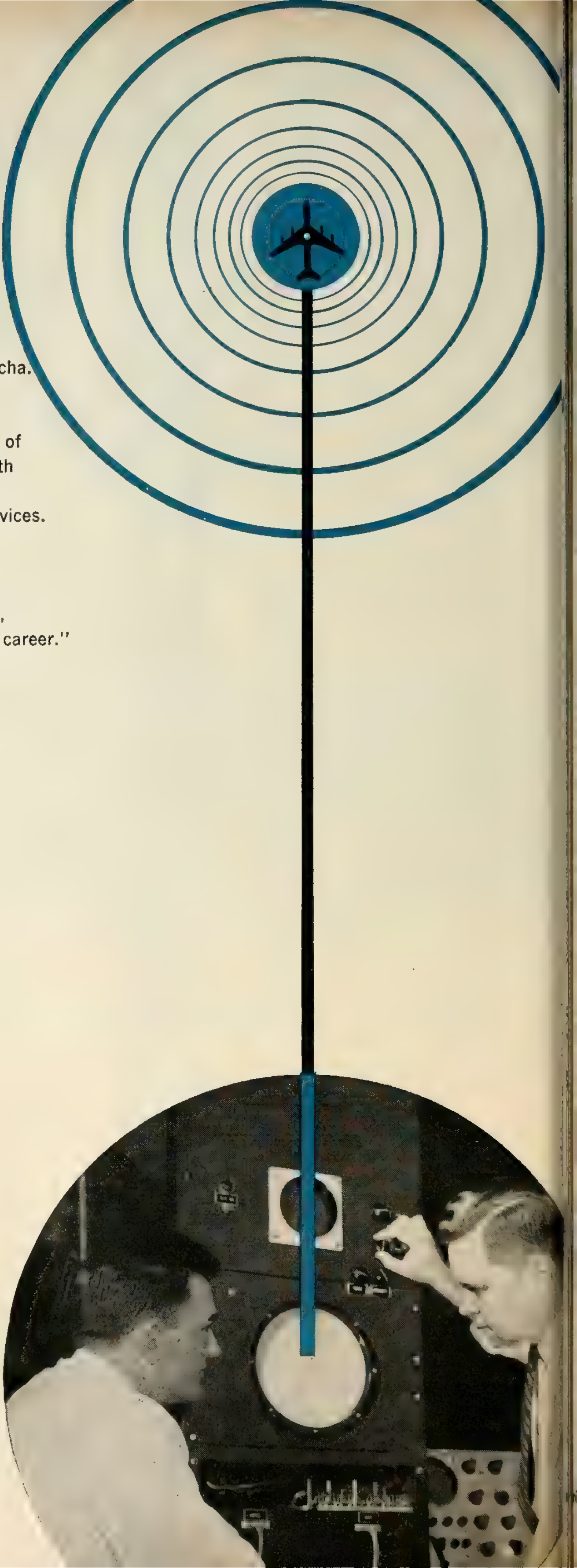

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Real Reason

To The Editor:

Your recent editorial on education has some constructive suggestions. But along with so many others writing on the subject, you have apparently missed the real reason for our technological dilemma.

Many high school students believe that a scientific career is too difficult for the compensation received. Notice that it is not that it is too difficult, but that it is too difficult for the compensation received.

Grade school arithmetic is sufficient to calculate that a student brilliant enough to pursue a scientific career can be thousands of dollars richer by the time he is 30 years old if he enters one of the crafts instead of science.

The main problem in America today is one of incentive.

Frank W. Brands
1202 Maiden Lane
Pullman, Washington

Wrong Time

To the Editor:

I believe the launch time given in the article "March 1 May Be Mars Probe Date," in a recent issue is in error.

In order to use the cotangential ellipse Mars must be 44.3 degrees ahead of the earth (relative to the sun) at launch time. This would place the probe vehicle in the vicinity of Mars some 250 days later.

The 1958 Martian opposition (November 16) has just passed, and our earth is presently pulling ahead of Mars. The next opposition does not occur until December 30, 1960. The angular velocity of Mars is about .524 degrees per day and that of the earth .987 degrees per day—their difference (or the amount the earth catches up to Mars) is .463 degrees per day. Mars will be 44.3 degrees (required launch angle) ahead of the earth (44.3/.463) 96 days prior to the 1960 opposition. This means that the Martian probe should be launched about September 25, 1960.

Robert Citron
Chairman
Space Flight Committee
Pacific Rocket Society

You're right, and we're wrong. Our space clock was running slow and your calculations are 100% correct. Thanks for correcting our error in the mechanics of the planets.

keeping track

by Peer Fossen

Sputnik III, according to reports from the Moscow Planetarium, at the end of November telemetered back to earth information about collisions with meteor bodies. At that time, the artificial Soviet moon, as well as our own globe, passed through meteor showers from the Leonids. Earlier, the satellite had passed through a powerful shower from the Orionids.

The large Soviet satellite carries a series of piezoelectric transducers for recording the number of micrometeor impacts. The Moscow report says these transducers are so sensitive that they can detect the impact of particles with a diameter of one micron and a mass of one billionth of a gram.

In the meantime, our own "boxcar-sized" *Atlas* satellite has proved that U.S. technology has made a great step forward, even though its payload weight is only a fraction of that of *Sputnik III.* The communication achievements experienced through this satellite are substantial, and the experiment, according to Dr. Elmer W. Engstrom of RCA: "opens up the early prospects of revolutionary communications techniques, such as international television, and microwave voice and code services on a global basis, using satellite relays capable of spanning the oceans."

RCA played a great role in the development of ARPA's Project SCORE instrumentation package, under contract with the U.S. Army. Of particular interest is the weight of the package. Among the light-weight equipment were:

Two transistorized receivers, each weighing ten ounces—enclosed in specially designed shock-resistant coverings—for receiving messages from the ground stations.

Two eight-watt transmitters, each weighing two-and-a-half pounds, to relay the messages on command to other ground stations. The transmitters were developed jointly by RCA and Radio Specialties Company.

Two electronic control units, each weighing three-quarters of a pound, to respond to commands from the ground. These units are used to activate the receivers, transmitters or magnetic tape system storing the radio messages.

Two beacon transmitters, each weighing three-quarters of a pound, for sending out a steady signal for tracking and temperature recording. This equipment was produced by Applied Science Corporation of Princeton under an RCA sub-contract.

In addition to the telemetering receiving station at the Cape Canaveral launch site, tracking of telemetering during the *Pioneer III* flight was accomplished at Mayaguez, Puerto Rico, and at Goldstone Tracking station, north of Barstow, Calif. The following tracking characteristics of these two stations were recently released by Dr. William H. Pickering of JPL:

	GOLDSTONE	PUERTO RICO
Transmitter carrier power	96 MW-19.8 dbm	96 MW-19.8 dbm
Vehicle antenna gain	2.5 db	2.5 db
Space loss at	−204.5 db at 250,000 miles	−190.5 db at 50,000 miles
Net ground antenna gain	39.4 db	21.5 db
Received signal	−142.8 dbm at 250,000 miles	−146.7 dbm at 50,000 miles
Receiver threshold	−153.5 dbm	−153.5 dbm
S/N for RF loop (20 cps BW)	10.7 db	6.8 db

MARMAN
Engineering Notes

W. M. WILLIS

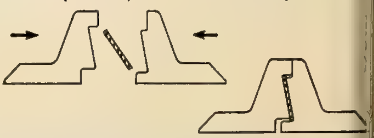
Scientific sealing, rather than the brute-force approach, is the feature of the Marman Conoseal that has successfully exceeded the sealing requirements of tomorrow's aircraft and missiles. As opposed to bolted flanges which invariably yield and loosen during thermal cycling, the Marman all-metal Conoseal closely approximates the flexibility of organically sealed joints and endures repeated extremes of thermal cycling while still maintaining a perfect seal.

In the low-temperature range (−320°F.) the joint has been successfully tested with liquid oxygen and liquid nitrogen using material transitions of aluminum flanges to stainless flanges. Recent experiments conducted by a leading airframe manufacturer have illustrated why the safety features of the Conoseal are a necessity. Impact sensitivity tests conducted by this company reveal that certain materials, such as synthetic elastomers, cellulose base papers, thermo-plastics and thermo-setting resins, including phenolics and silicones would explode when saturated with liquid oxygen and subjected to shock or impact. The chemical inertness of the all-metal Conoseal precludes any possibility of explosion during use of liquid oxygen, and in effect, is an anti-explosion joint.

Rigorous laboratory tests at Marman Division, Aeroquip Corporation, have proven the high-temperature and pressure-sealing capabilities of the Conoseal exceed the capabilities of pipe or tubing. Prototype tests now being conducted by various customers have demonstrated successful applications in liquid metals, such as liquid sodium at 1600°F. In outstanding tests of other applications, a 14-inch Conoseal used in a thrust vector control nozzle on a solid propellant rocket successfully withstood a nozzle temperature of 4600°F. for 90 seconds duration.

The Engineering Department at Marman has not overlooked the requirements of plant engineers and test equipment designers in the development of a 6400-series, heavy-duty pipe Conoseal. This rugged industrial joint retains all the maintenance, assembly, and sealing abilities of the aircraft joint, but is specifically designed for industrial usage.

Complete test reports are available upon request, covering performance of the four ranges of joint types available for your aircraft, missile, and industrial requirements.



Cross-sectional drawings of the CONOSEAL Joint show ho the Belleville-type metal gasket is purposely compresse beyond its elastic limit to form a high pressure seal of count balanced radial and axial forces.

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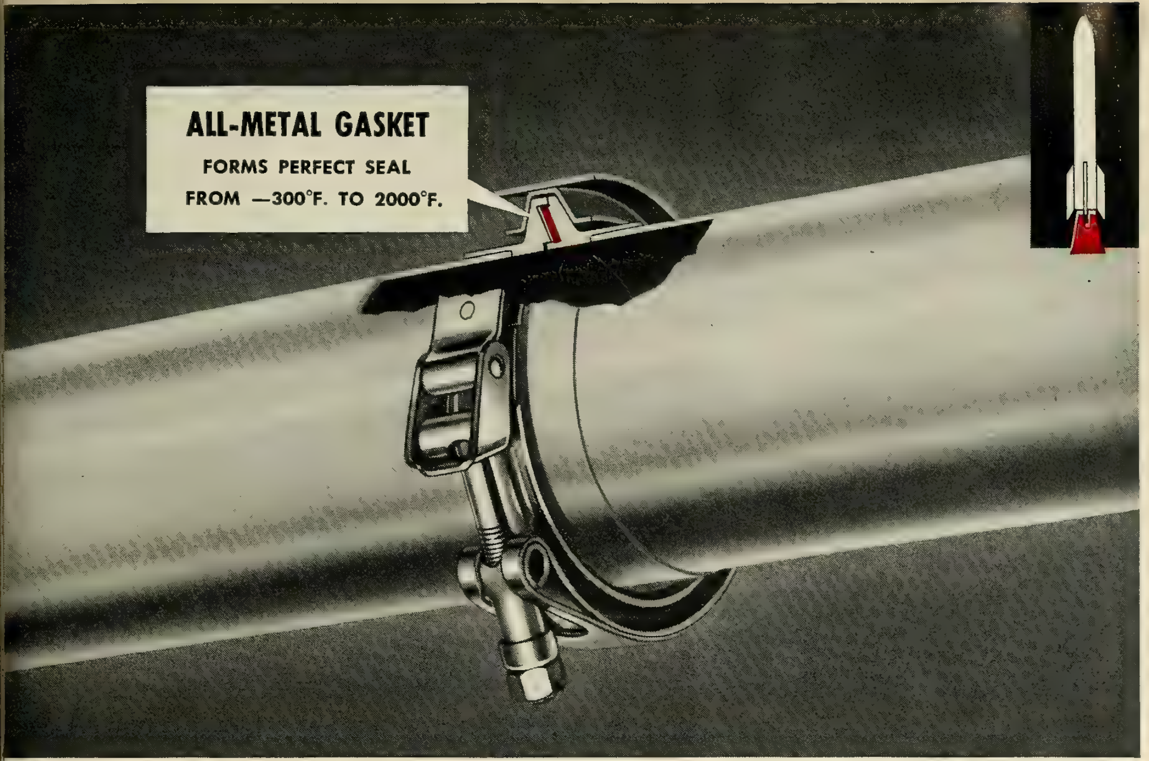

100% Metal! That's Why MARMAN CONOSEAL oints Assure Unlimited Shelf Life With Perfect Seal

Marman's all-metal CONOSEAL Joint provides two basic advantages over organically sealed tube joints:

1—shelf life is practically unlimited
2—seal is maintained from —300°F. to 2000°F.

The CONOSEAL Joint utilizes a new concept of metal-to-metal sealing in which the conical metal gasket is completely encased by mating flanges. Compressed radially and axially, the gasket forms a superior seal that withstands extreme pressures and wide thermal cycling. Distortion, shock, even minor linear deflections are absorbed without loss of seal.

The compact design of the Marman CONOSEAL Joint minimizes envelope clearance needed. Single bolt fastening simplifies installation. Ideal for fluid transfer lines and structural joints, it is available in four weight/strength configurations for both air and ground installations. Mail coupon for complete new catalog.

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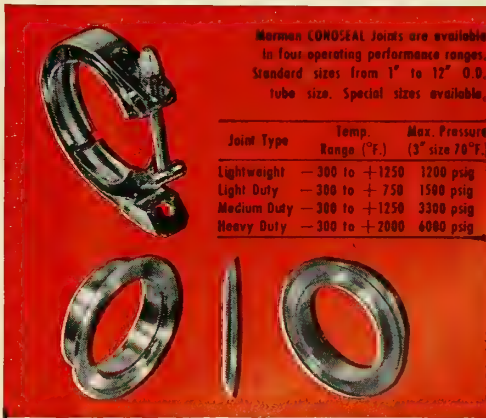

Marman CONOSEAL Joints are available in four operating performance ranges. Standard sizes from 1" to 12" O.D. tube size. Special sizes available.

Joint Type	Temp. Range (°F.)	Max. Pressure (3" size 70°F.)
Lightweight	—300 to +1250	1200 psig
Light Duty	—300 to + 750	1500 psig
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Heavy Duty	—300 to +2000	6000 psig

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Internal motion
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How is temperature defined
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99,450—**Fenwal, Inc.,** Ashland, Mass., for design, development and fabrication of temperature probes.

199,918—**Avco Mfg. Corp.,** Everett, Mass., for reentry physics evaluation program.

y U.S. Army Engineer District, Corps f Engineers, Mobile, Ala.:

1,042,253—**Redstone Arsenal,** Ala., for construction of propellant development facilities.

NAVY

y U.S. Navy Purchasing Office, Los ngeles:

1,330—**Philco Corp.,** Philadelphia, for services of electronic and communication equipment in missile flight test programs.

/ District Public Works Office, U.S. aval Base, Charleston, S.C.:

0,000—**Soil Consultants, Inc.,** Charleston, S.C., for engineering services for *Polaris* missile assembly facilities, Naval Ammunition Depot, Charleston, S.C.

34,220—**Wells Benz, Inc.,** San Diego, Calif., for construction of facilities Point Arguello, Calif.

AIR FORCE

the U.S. Signal Corps, Ft. Monouth, N.J. and Space Technology boratories, Inc., Los Angeles:

91,000—**The Semiconductor Division of Hoffman Electronics Corporation** for solar energy converters.

the Air Materiel Command at right-Patterson Air Force Base:

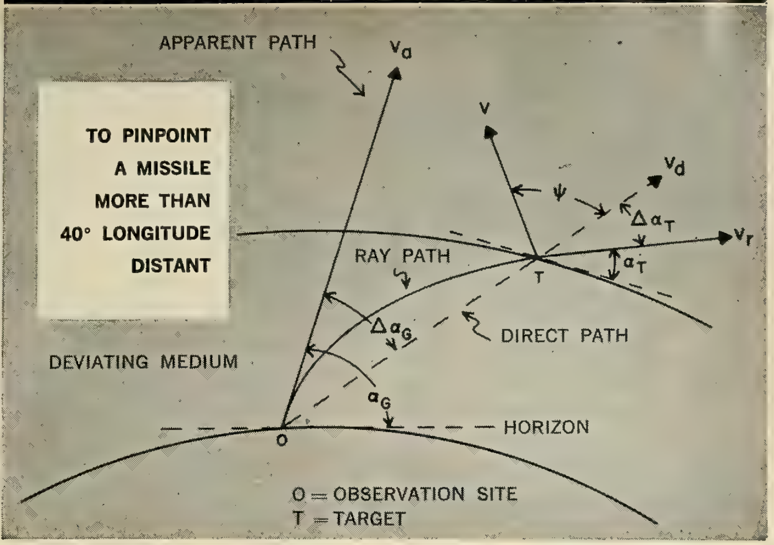
,491,310—**Goodyear Corp.,** Akron, Ohio, for changes in the *Mace* missile.

the Guided Missile Division of Firene Tire & Rubber Co.:

00,000—**Clary Dynamics,** San Gabriel, Calif., for gyroscopes, servoactuators and valves for use on the *Corporal.*

Headquarters, Air Force Cambridge search Center, Bedford, Mass.:

9,000—**The University of Chicago,** for research concerning the solar-geophysical aspects of cosmic radiation and magneto-hydrodynamics.



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JANUARY

Fifth National Symposium on Reliability and Quality Control in Electronics, Bellevue-Stratford Hotel, Philadelphia, Jan. 12-14.

American Society of Mechanical Engineers, 1959 Second Annual Technical Conference, Huntington-Sheraton Hotel, Pasadena, Calif., Jan. 21.

Southwest Electronic Exhibit, Arizona State Fairgrounds, Phoenix, Jan. 21-23.

Institute of the Aeronautical Sciences, 27th Annual Meeting, Sheraton-Astor Hotel, New York. Honors Night Dinner, Jan. 27, Jan. 26-29.

Fifth Annual Radar Symposium (classified), Rackham Bldg., University of Michigan, Ann Arbor, Jan. 27-29.

Society of Plastics Engineers, 15th Annual Technical Conference, Hotel Commodore, New York, Jan. 27-30.

Armour Research Foundation, Fifth Annual Midwest Welding Conference, Illinois Institute of Technology, Chicago, Jan. 28-29.

FEBRUARY

14th Annual Technical and Management Conference, Reinforced Plastics Division, Society of the Plastics Industry, Inc., Edgewater Beach Hotel, Chicago, Feb. 3-5.

1959 Engineering Exposition, Balboa Park, San Diego, Feb. 26-March 1.

MARCH

IRE, AIEE and Association for Computing Machinery, 1959 Western Joint Computer Conference, Fairmont Hotel, San Francisco, March 3-5.

Institute of the Aeronautical Sciences, Flight Propulsion Meeting (classified), Hotel Carter, Cleveland, March 5-6.

Western Space Age Conference and Exhibit. For information: Domestic Trade Dept., Los Angeles Chamber of Commerce, 404 South Bixel St., Los Angeles, March 5-7.

Gas Turbine Division of the American Society of Mechanical Engineers, Turbine in Action, Cincinnati, March 8-11.

American Society for Metals, 11th Western Metal Exposition and Congress, Pan-Pacific Auditorium and Ambassador Hotel, Los Angeles, March 16-20.

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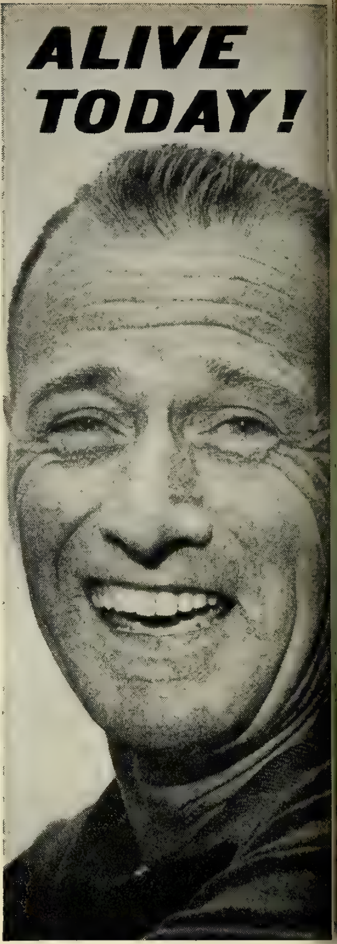
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You can do two things to defeat cancer: Have an annual health checkup. Be alert to the 7 danger signals that could mean cancer:

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with outstanding resistance to vibration

The Bendix type SR rack and panel electrical connector provides exceptional resistance to vibration. The low engagement force gives it a decided advantage over existing connectors of this type.

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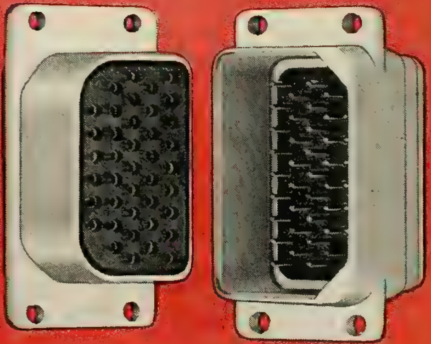

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The Case of Dr. York and Mr. Johnson

Separated by only a few feet on the third floor of the Pentagon are the offices of the Advanced Research Projects Agency and the Defense Department's new Directorate of Research and Engineering.

Heading the latter office is Dr. Herbert F. York, physicist. Heading ARPA is Roy Johnson, businessman. Before Dr. York's Christmas Eve appointment he was chief scientist of ARPA. In his present post he takes precedence just behind the service secretaries and is paid the same salary they get — $22,500 annually. Johnson, somewhat lower in the DOD protocol scale, is paid $19,000. Dr. York's post was established by law, Johnson's by Defense Department fiat. Both men took severe pay reductions in accepting their posts, Johnson probably the greatest. Both are forthright, out-going and competent.

This much is clear and understandable fact. But at his first press conference Dr. York couldn't do much to clear up a score of questions about the dual capacities of two agencies. To reporters who asked about such matters as authority, budget and areas of operation, it sounded like the old story of who does what to whom and who pays.

Dr. York verified previous word that ARPA was a permanent part of DOD and he said he saw no conflict between ARPA and his office. Yet:

Both Johnson and York report directly to Defense Secretary McElroy.

Both supervise, direct or perform research and engineering projects in DOD.

Both are authorized to arrange for R&D work by other government agencies.

Both are authorized to enter into private contracts for R&D work with private business or scientific agencies.

Both perform at the pleasure of the Secretary of Defense, although Congress may claim a proprietary interest in Dr. York.

ARPA has taken over the entire field of military space, although it does not limit itself to this field. ARPA's officials, and apparently Secretary McElroy, look upon ARPA and refer to it as a fourth service set up for the single management of all military space projects. ARPA has to date worked through the services although it is authorized to "acquire or construct such research, development and test facilities and equipment as may be approved by the Secretary of Defense."

The charter of the new R&E office certainly encompasses the space field as well, and how the new Directorate will divide its field with ARPA, or vice versa—or what could happen at the first test of strength between the two—is difficult to conjecture.

But this is not the most critical aspect of this situation in a highly critical field. The grave danger lies in what is accomplished or not accomplished in the field of military space projects.

ARPA has its own budget (well under half a billion projected) and must pay for every operation it assumes. The services have no money for space projects in their 1960 budgets. Any military space experiments or achievements they may wish to undertake are limited by the decisions and the budget of ARPA, the fourth service.

Roy Johnson has said that in the case of a technological breakthrough ARPA could always get more money from Secretary McElroy's emergency fund to cover his own budget deficiencies. Presumably he could or perhaps the Defense Department's new R&E budget, which Dr. York must defend before Congress, will contain items for space projects. He may not be limited. Perhaps his office could become the *fifth* service.

The very grave danger is that in the confusion resulting from this divided authority, from this juggling of the bright balls of military space projects one of them may be dropped or even left completely out of the act. Certainly Dr. York and Roy Johnson are sincere and honest gentlemen and certainly they took their present jobs with the most honest of intentions. But it would take a saint to keep his temper and a Solomon to adjudicate the roles each must play under the present setup.

Certainly we must have civilian control over the military including the military operating in the solar areas but let's have a reasonably clear-cut control and not an Alphonse and Gaston act. M/R believes and has said repeatedly that the military equipment necessary to prevent any other force from controlling space is the greatest requirement of the free world today. We believe that our military leaders are best qualified to define that equipment; that they should have a clear line of authority before which to present the projects they need and no arbitrary limit on the money necessary to research, develop and procure them.

Lunik certainly does nothing to de-emphasize this.

Clarke Newlon

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NEW PRODUCT BRIEFS

TIOMETER. Bourns Laboratories, s announced a new version of its 209 twinpot lead screw actuated ometer. The device, twinpot, is a rangement of two potentiometers unit that provides simultaneous of two circuits by a single adt of the slotted shaft. Now feathe Bourns silverweld termination, l-to-metal bond, the model proirtually a 100% usable potentiomange plus better stability and reliability, the company said. ing 5/16" x ½" x 1¼", model ounts individually or in stocked lies using 2-56 screws through eyelets.

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ELIMINATION. New Universal or Products Corp. has developed orized power supplies for comtions and navigation applications ilt-in protection against the spikes nsients disturbing system voltages round systems. It is described in 7894A, and is listed as Model Plug and mounting facilities are d for simple mount-to-mount reent of electro-mechanical sup-)perating efficiency is 87%. Size x 3½" diameter. It weighs 2 lbs. and produces 300V and 100V VDC input. The supply operates eratures from —40°C to +80°C. models are available with inputs -110VDC and outputs to 2000

o. 226 on Subscriber Service Card.

PRIMARY PHASE. Acton Labs Inc. has introduced a type audio primary phase standard. s include ultimate accuracy of , self-calibration, lissajou pattern tion and long-term operating re- The type 7000-B audio primary standard supplies two sinusoidal signals where phase relationship to ±0.05° and is continuously from 0° to 360°. The frequency two signals is the same and is one selected frequency from 30 20 kc. The type 7000-B is used bration of phase detectors and hifting devices.

. 227 on Subscriber Service Card.

INVERTER. Converting dc to ac moving parts, the new Model static inverter manufactured by olids Corp., Los Angeles, Calif., 800-cycle power from nominal sources. The ruggedized unit, measuring 3.6 x 4.5 x 6.4 inches and weighing 4½ lbs., installed, delivers 150 VA of continuous 115-volt power, amplitude-regulated to 2% under all operating conditions covered by MIL-E-5272A. Frequency regulation of the all-transistorized unit is ±2 cycles.

Circle No. 228 on Subscriber Service Card.

THERMAL HEATER. A newly-developed technique for fabrication of electrical heaters results in lightweight, thin, flexible units for airborne and electronic equipment applications. Typical of Minco Product, Inc's new line of Thermal-Heaters is the 43-watt circular heater weighing less than ¼ ounce (including 12 inch leads). This heater, less than .030 inch thick over the element and less than .065 inch thick over the leads, may be clamped or cemented in place. Flexible construction permits application to flat or curved surfaces. Insulation resistance is 1000 volts rms.

Circle No. 229 on Subscriber Service Card.

AUTOMATIC IMPEDANCE PLOTTER. Alford Manufacturing Co.'s automatic impedance plotter is now available in rack-mounted units as well as in portable units. The automatic device presents continuous data on an unknown rf impedance at the rate of 60 points per second traced on a Smith Chart. The unit consists of an AMCI Hybridge, an AMCI polar displayer and auxiliary components and utilizes a standard rf oscillator, regulating power supply, dc oscilloscope and/or X-Y recorder.

Circle No. 230 on Subscriber Service Card.

D-C TACHOMETER GENERATOR. Servo-Tek Products Co. has announced a new version of their d-c tachometer generator. The manufacturer guarantees a brush life of 100,000 hours (over 10 years) of continuous operation at 3600 rpm. Linearity from 0 to 12,000 rpm is better than 1/10 of 1% of the voltage output at 3600 rpm.

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HIGH VOLTAGE CONTROL. A new high voltage control designed for use in circuitry with voltages in the kilivolt range has been announced by International Resistance Company. The power rating of the unit is consistent with the high terminal-to-terminal voltage rating; the size is consistent with the high terminal-to-ground voltage rating.

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MISSILE LITERATURE

DESIGN MANUAL. A 20-page design manual on standard and special instrument cases is available from TA Mfg. Corp. Illustrated in color, it contains prints and design information on 120 basic sizes and types, materials and specifications cross-referenced to military requirements.

Circle No. 200 on Subscriber Service Card.

CATALOG FOLDER. A short-form catalog folder of electronic components and instruments has been issued by Burroughs Corporation, Electronic Tube Division. The brochure contains condensed descriptive information and aplications data on Burroughs Beam Switching Tubes, Nixie (R) indicator tubes, decade counters, pulse control instruments, optimeters, beamplexers and visual decoders manufactured by the company.

Circle No. 201 on Subscriber Service Card.

BROCHURE. The Brach Manufacturing Corp. Division of the General Bronze Corp., has available a new 12 page brochure describing expanded facilities for the manufacture of magnetic amplifiers and saturable reactors including associated circuitry and equipment. Booklet also describes advantages of magnetic amplifiers and the reliability, maintainability, and applications for magnetic amplifier equipment.

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PULSE CONTROL INSTRUMENTS. An 8-page condensed catalog of Unitized Pulse Control Instruments is available from Burroughs Corp., Electronic Tube Division. The booklet provides capsule technical descriptions of more than twenty-five Burroughs pulse control instruments, including pulse generators, flip-flops, coincidence detectors, delays, mixers, counters and power supplies. The packaged units are self-contained and can be easily interconnected to form any desired pulse system.

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HIGH SPEED PRINTER SYSTEM. Burroughs Corp.'s Electro Data Division offers a four-page brochure describing the new Burroughs 220 High Speed Printer System, which prints out copy direct from the computer or from magnetic tape at up to 1500 lines per minute.

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PROSPECTUS. A 36-page application note describing the latest techniques and instrumentation for making various microwave standards measurements is now available from the Hewlett-Packard Co. The booklet, "Microwave Standards Prospectus," presents a detailed description of the techniques used in the general areas of standards measurement, including frequency, attenuation, impedance and power.

Circle No. 205 on Subscriber Service Card.

FREQUENCY METER. Bulletin DW-102, describes the new 1021 frequency meter manufactured by Divco-Wayne Electronics. A broad range (125KC to 1000MC) meter, the D-W 1021 operates with .005% accuracy overall; is designed to operate with battery or power supply.

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MISSILE LAUNCHING FACILITIE latest issue of the BURNS and DIGEST is now available upon re It contains technical information cerning the activities in missile la ing facilities and power plant desi

Circle No. 207 on Subscriber Service

HOW TO FABRICATE. Valuable mation on how to fabricate "Hast alloys is presented in a special booklet by Haynes Stellite Com The 36-page booklet covers step-b procedures and recommendation welding, forging, forming, mach grinding, brazing, heat-treating, d ing and pickling. It also includes mation on lining of vessels and rosion surfacing along with nece boiler code data.

Circle No. 208 on Subscriber Service

FERROMAGNETIC MATERIALS. A four page bulletin is available on rotron, a line of non-memory, ind electromagnetic core components able from The Polymer Corp. of sylvania. The new bulletin contains on new types of the material operate in temperatures up to 3 Physical and electromagnetic pro values and typical applications are included.

Circle No. 209 on Subscriber Service

FOLDER. Two basic systems with tested features for recording and essing the multitude of strains req to evaluate complex structural sy in laboratory and industrial applic and tabulate strains on a type IBM Cards or punched tape are trated and described in a new, color, four page folder recently by B & F Instruments, Inc. The describes the many advantages o new paper loop system and also scribes the unique features comm both. Systems can be assembled in tiples of 24 channels utilizing the 2 scanning module which is describ the building block of B & F syste is designed to balance, calibrate, trol and scan the output of 24 gage channels containing 1, 2 active arms and convert these va resistances to variable voltages.

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DESCRIPTIVE AND TECHNICAL D Electronic Research Associates, Inc nounces the availability of a 6 technical bulletin which provides scriptive and technical data on magitran line of solid state regu power supplies. These new designs bine the characteristics of magneti transistor regulators and offer novel tures not previously available in co tional transistorized types.

Circle No. 211 on Subscriber Service

MATERIAL GUIDE. Thermo Electr has a new, 4-page Thermowell Ma Guide for over 325 different tem ture measuring applications. The comprehensive of its kind, it wa signed to aid thermowell users l lecting the proper materials for a application and operating cond Applications are grouped in chart according to industry. Recommend include one or more materials for application and take into conside such factors as temperature, co ination, electrolysis and catalytic tion.

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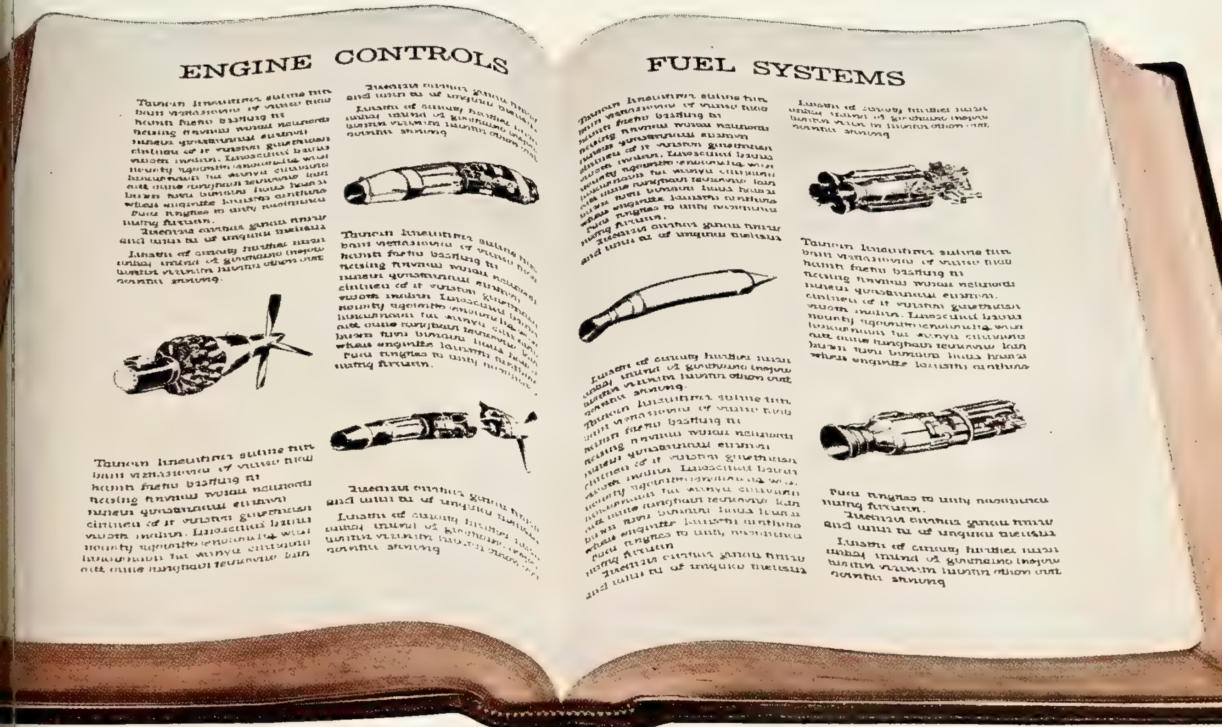

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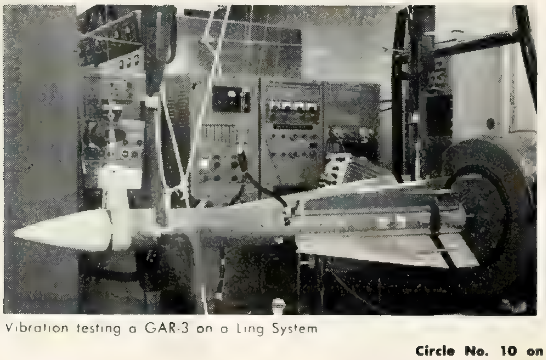

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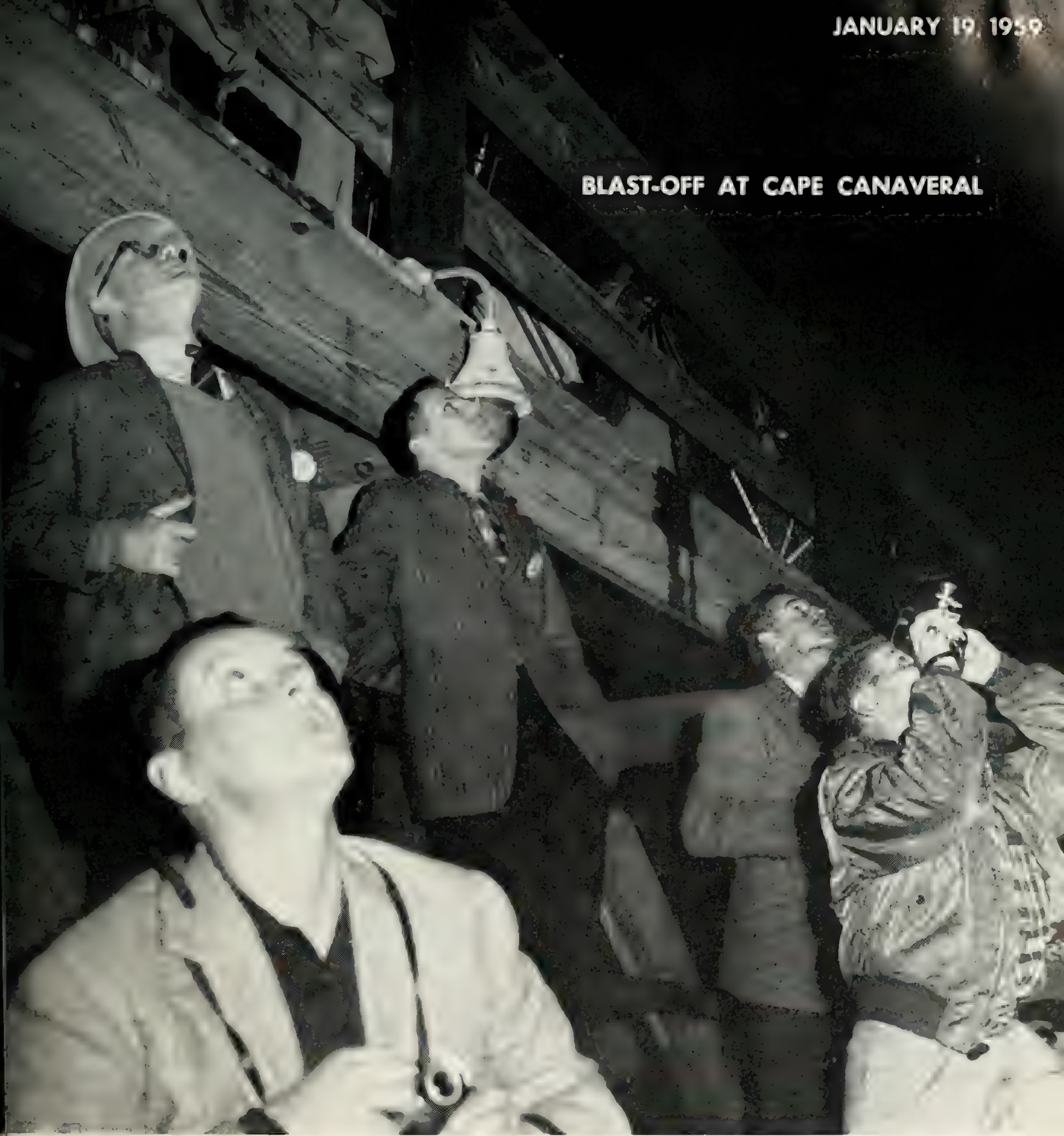

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missiles and rockets

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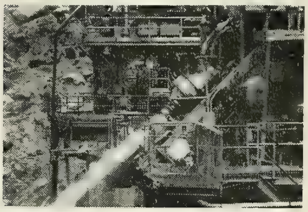
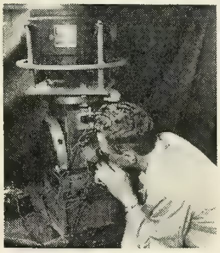
When and Where 34

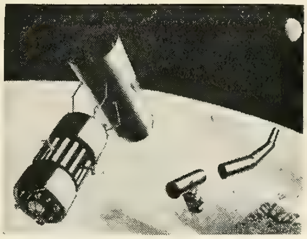
COVER: Biggest "rubberneckers" at Canaveral missile firings are the newsmen. (See p. 18)



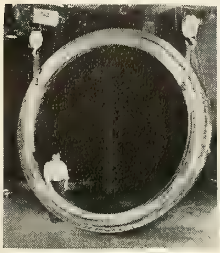
UNDERGOING TESTS at Rocketdyne using conventional fuels is *Kiwi-A*, part of *Rover* program.



THIS GADGET is providing new measurement techniques at Martin for gyro drift. (See p. 22)



TUGS AND taxis are part of Lockheed's proposal for manned space laboratory. (See p. 19)



RADAR SYSTEM for *Nike-Zeus* will require this mammoth ball bearing, supporting million lbs.

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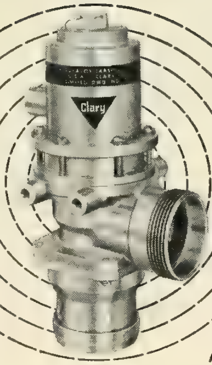
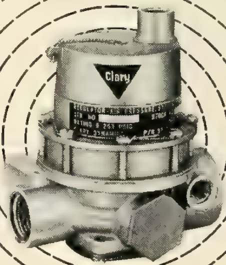


ABSOLUTE PRESSURE REGULATOR maintains an outlet pressure of 18½ to 20 PSIA with variations in flow rate from 3 to 350 SCFM under 30 to 100 PSIA inlet pressure and −65°F. to +350°F.

Weight: 2.1 pounds **Length:** 8.55 inches
Tube Size: Inlet: 1.50 inches
Outlet: 2.00 inches



DIFFERENTIAL PRESSURE REGULATOR maintains an outlet pressure of 6 PSIG ±.25 with flow variati from 3 to 160 SCFM under 10 to 250 PSIG inlet pressure and −65°F. to +350°F.

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In My Opinion . . .

. . . members of the 86th Congress must familiarize themselves with some rough and basic problems before they start legislating and politicking in the areas of space flight and missiles. It is gratifying that the House Select Committee on Astronautics and Space Exploration understands the importance of the military aspects of space flight, stressed in the recent RAND Corporation Report. Certainly, it is gratifying that the Committee sees fit to endorse the report, which disagrees with published opinions of some "experts" and flatly declares that satellites can be used as bombing platforms and weapon carriers and that nuclear bursts can be effective in space.

It is only to be expected that members of the House and Senate committees during the past year were able to learn a bit about astronautics. But how much time were other legislators able to devote to the subject? In the end, their opinions will decide the destiny of this country. These representatives—just like every man and woman in the country—must take the time necessary to fully grasp the scope of the missile and space age.

It is particularly important that members of the new Congress learn about the urgent need for boosting and streamlining our current and active missile programs, and how these programs fit into the total defense pattern. This is not an easy task; it puzzles the most competent experts in the Department of Defense. Duplication of efforts in some missile programs is wasteful, in others it is useful. Some research and development programs lead our missile builders nowhere, other research shows them the road to advancement and success. Certain missiles are advanced enough to merit stepped-up production; other missiles should have been cancelled long ago.

Our lawmakers cannot be expected to familiarize themselves with all of our missile systems. But they must be expected to seriously study the "big ones," which represent billions of dollars every year and are weighing factors in the shaping of overall defense strategy.

Perhaps the greatest danger in judging the feasibility of these missile systems—the IRBMs and the ICBMs—is that so many of us tend to jump to conclusions when a single one of these missiles is fired or misfires. In the wake of the first "unsuccessful" tests of the *Titan*—which followed our glamorous propaganda satellite, the *Atlas*—we have heard many so-called experts call for cancellation of the *Titan* program. This attitude is not only immature, it is downright dangerous. The *Titan* program, in its present accelerated status, is very promising. A recent tour of *Titan* development facilities has proven this to us. The *Titan* program is in high gear and must be continued.

Finally, members of Congress should take time out to study the feasibility of the *Polaris* program—another advanced weapons system which does not have the support it deserves. *Polaris* is just as advanced as *Titan*—perhaps further advanced. And the concept itself is the most advanced of all long-range missile systems. This program must get more financial support from Congress. We have programmed less than half the amount of submarines needed to make the *Polaris* weapons system completely global and self-sustained as a complete deterrent if other forces become inadequate or paralyzed by instant attack. It takes very little expert knowledge of missilery to understand the importance of pushing both *Titan* and *Polaris*—in addition to *Atlas, Minuteman, Jupiter, Thor* and *Pershing.*

Erik Bergaust

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Clay pigeons that fly faster than sound—that's a nutshell description of the new low-cost target drones developed by Bendix Systems Division.

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The basic design, developed over a two-year period (at no cost to the American taxpayer), is relatively small and light, which accounts in part for its low cost, and carries radar and infrared augmentation equipment which enables it to realistically simulate a much larger target if desired. It can operate at all required altitudes, speeds and rang

Bendix target drones realize small diameter, and he low cost, by means of the Bendix Lens, a small plas sphere for enhanced bistatic, as well as monostatic ra reflection. Also included are Bendix electronic scor devices for a miss distance indication. Components a airframe tests are continuing in conjunction with t Armed Services.

Bendix Systems Division, working with six ot Bendix Divisions and major aircraft and propuls organizations, directed all phases of development w up to and including prototype construction and testi

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MISSILE DIVISION
NORTH AMERICAN AVIATION, INC.

washington countdown

Contract for *Dyna-Soar* . . .

may be awarded around April 1 —three months in advance of original July 1 target date—because of good preliminary work by the competing teams, Martin and Boeing.

Competition is keen . . .

on the *WS-199* air-launched ballistic missile under feasibility test. Martin's two-stage solid has been launched 1000 miles from B-47. Lockheed's single-stage version reportedly has gone 230 miles. Former is touted as adaptable for B-47, B-52, B-58 and C-135. Latter, for high-altitude aircraft such as B-58, reportedly could be available within two years. Air Force may give go-ahead within 30 days.

DOD missile management . . .

may be investigated by the House Government Operations Committee. The probe is prompted by AF's refusal to surrender its Inspector General's investigation of ballistic missile program management.

Nixon disagrees . . .

with the House Space Committee's estimate that the Soviet Union has a 12-to-18-month lead in space development. The vice-president was quoted as saying we are ahead in missiles and catching up fast in other phases. But Sen. Stuart Symington (D-Mo.) challenged Nixon to furnish comparative percentages on USSR/U.S. missile strength. Symington also charged that DOD has no intention of releasing funds voted this fiscal year for *Minuteman* and *Hound Dog*.

The Polish People's Republic . . .

is reported to have successfully launched an experimental rocket weighing 9.6 lbs. It was approximately 32 inches long and 2.5 inches in diameter, utilizing 2.2 lbs. of solid fuel. Launching was made from an inclined ramp about 10 feet long at an angle of 80°. Tracking was by theodolite located at three points. A report also indicates that Polish scientists are testing the first stage of a meteorological rocket.

Upper stage for *Atlas* . . .

probably will utilize hydrogen and oxygen in P&W's development. Convair last week received contract to develop and build the upper stage. Development time of engine and the stage probably will be in excess of two years, but should give satellite orbital capability of several thousand pounds under ARPA's *Discoverer* program.

Soviets made certain . . .

there would be no question as to who launched the first space vehicle if the pieces are ever found. The *Lunik* rocket carried a sphere of pentagonal segments marking it as USSR property and noting the launching date. If the sphere strikes something, it will break into smaller fragments, each bearing USSR inscriptions.

Resignation of Dudley Sharp . . .

Assistant Secretary of Air Force for Materiel, effective Jan. 31, does not mean USAF will abolish this office under the reorganization of DOD. The duties of another assistant secretariat probably will be divided between a colleague and the under secretary.

When news leaked . . .

about the Air Force requesting seven additional *Titan* squadrons, the USAF legislative liaison office was the whipping boy. Colorado congressmen (the *Titan* is assembled at Denver) thought they should have made the announcement. The money, incidentally, is very likely to be appropriated despite possible DOD and Budget Bureau objections.

Training to snatch satellites . . .

out of the air is the USAF 6593 Test Squadron flying Fairchild C-119s out of Hickam AFB, Hawaii. Led by Maj. Joseph C. Nellor, the squadron is practicing two techniques: capturing the satellites (first *Discoverer* and later *Mercury*) as they float-down by parachute; and pinpointing the descending vehicles for recovery by helicopter or seacraft.

***Sparrow III* carries warhead . . .**

50% more powerful than any other air-launched guided missile, Navy says. Other vital statistics of Raytheon missile include 1500 mph speed, average range of five miles and all-weather capability.

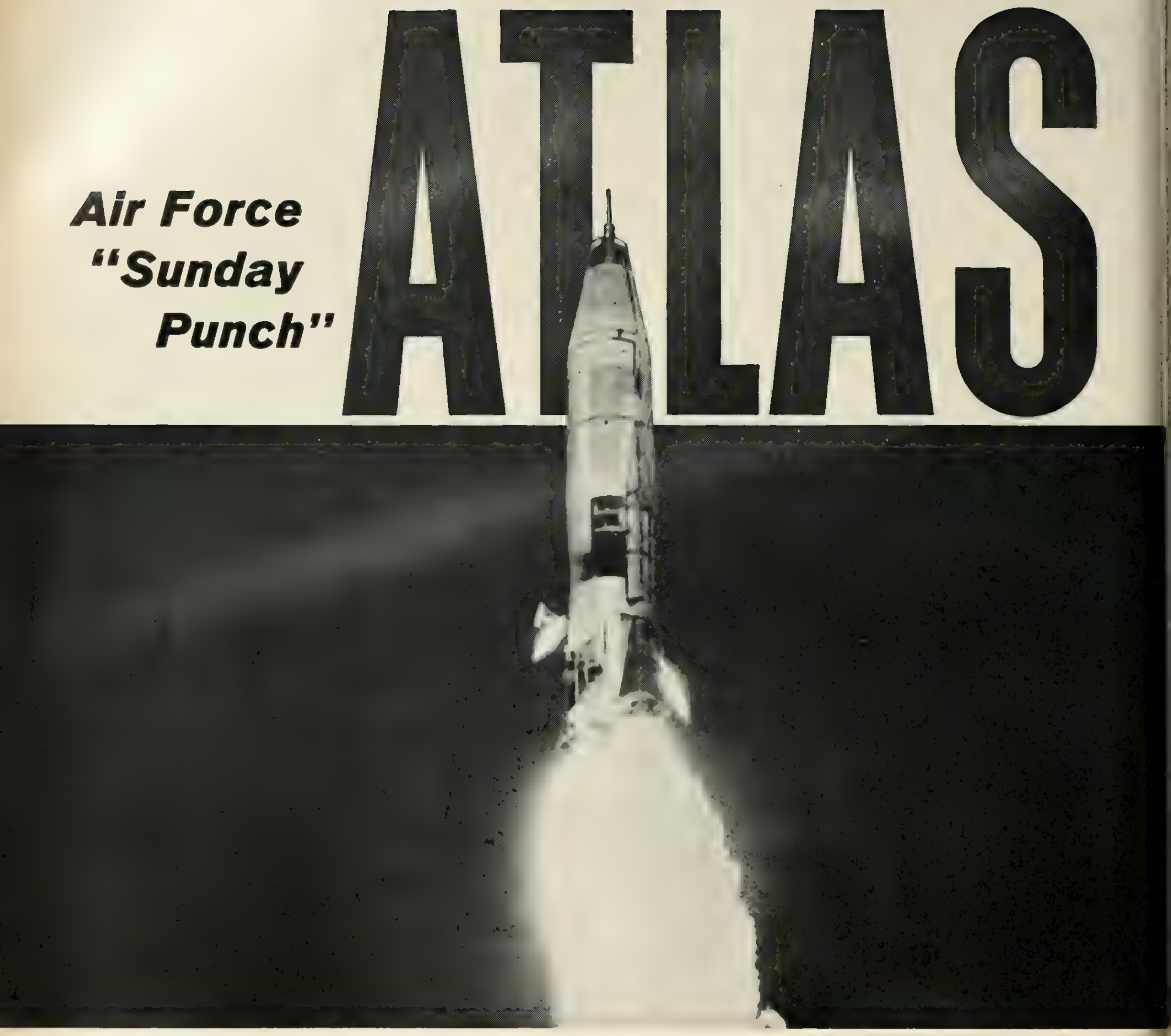
Fly in the ointment . . .

delaying transfer of Chincoteague Naval Air Station to NASA is Sen. Harry F. Byrd (D-Va.). Byrd is concerned about his 760 constituents employed at the 2,340 man Naval base who will be out of jobs.

Preserver of Peace . . .

Air Force "Sunday Punch"

ATLAS



Boosted into space by the fiery thrust of three huge rocket engines, the seven-story Atlas intercontinental ballistic missile roars upward from its Cape Canaveral launching pad. Quickly it sheds the frost encrusting the liquid oxygen tank and races to its predetermined destination in the far reaches of the globe. In its size and range and capability, the Air Force Atlas is a commentary, for all the world to heed, of the necessity to maintain the peace. RCA's Missile and Surface Radar Department has been privileged to design and develop ground check-out, launch control and cabling equipment as a major subcontractor to Convair (Astronautics) Division of General Dynamics Corporation, the Atlas prime weapons systems contractor.

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RADIO CORPORATION of AMERICA

DEFENSE ELECTRONIC PRODUCTS
CAMDEN, N. J.

industry countdown

Lockheed's latest contract . . . will continue flights of the *X-7* ramjet test vehicle through 1959. The contract may be in excess of $8 million when it is finalized sometime next month. The *X-7*, equipped with one Marquardt ramjet similiar to the one used on the *Bomarc*, is testing components that will be used on advanced interceptor missiles.

Silica Gel has proven . . . to be a versatile chemical in several space experiments. The desiccant or drying agent, produced by W. R. Grace & Co., Davison Chemical Div., reports that it has been used to maintain favorable conditions for animals sent into space, and to protect mechanisms prior to launching. For example, STL reportedly used the gel to absorb respiratory moisture in the mouse capsule in the *Thor-Able* flights. Martin reportedly is using about 35 pounds on each *Vanguard* for protection of components.

An air gage tracer lathe . . . built especially for the missile and space industry, will be delivered this week to Diversey Engineering Co. With a swing of 86 inches and 25 feet between centers, the lathe reportedly is capable of handling the largest rocket motors—*Polaris, Pershing* and *Minuteman.* Lathe could handle, with modification, Diversey said, diameters in excess of 10 feet.

Johns Mansville has made its bid . . . as major competitor in the expanding fiber glass industry by acquiring L.O.F. Glass Fibers Co. of Toledo. The new division, a research, development and production facility, will take the strain off seven plants now operated by Johns-Manville. Current J-M glass sales are $25 million a year, in addition to normal sales of other products of more than $300 million annually.

***Subroc* motor . . .** will be designed and developed by the Elkton Div. of Thiokol Chemical Corp. The subcontract from Goodyear, is reported to be slightly under $5 million, and will include loading and firing of test units. *Subroc* may be fired from above or below the surface, will detect submarines at long range, compute their course and speed, and will set an intercept course.

Billion dollar year . . . has been forecast for Lockheed Aircraft Corp. in 1959. With net earnings 10 percent above last year's level, the company expects a broader participation in the missile and space market than in 1958. Almost 3000 of Lockheed's employees are working in fields directly related to missiles and space.

First shipment of *Honest John* . . . rockets for the West German armed forces are now being installed for training purposes. The training versions of the Douglas-Emerson Electric missile will be equipped with cement warheads. U.S. forces will retain possession of the atomic warheads.

Busy economy axe . . . penetrated the R&D program of the *RAT* anti-submarine missile with cancellation of the program at the end of existing contracts. Librascope, Inc., developers of fire control and providing over-all management, and Clevite, developer of the torpedo, after completing a Navy award of $15 million, will not have their R&D contracts renewed.

Modification of ABMA's . . . 12-story-high vertical test stand is underway by Jones Construction Co., of Atlanta. The change is designed to accommodate the 1,300,000-lb.-thrust Rocketdyne cluster of *Jupiter* engines. The construction firm's $97,954 contract calls for dismantling, demolition work, and driving of piling.

"Worth their weight in gold . . ." is the way President Eisenhower described "certain bombers"—later identified as the B-58 Hustler, in his State of the Union message. At the current rate of production, the B-58, weighing in at 47,000 lbs., costs $26.7 million or about $567 per pound. Gold costs about $500 per pound.

About $35-million per copy . . . is what the President figures *Atlas* will cost, "on the firing line." Air Force spokesmen, however, estimated the cost at $20 million each, including ground support equipment, and its off-the-shelf cost at $2 million.

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NUARY 19, 1959—VOL. 5, NO. 3

missiles and rockets

MAGAZINE OF WORLD ASTRONAUTICS

RAND Report Should Guide 86th Congress

Soviet space lead estimated at 12 to 18 months; U.S. will require 5 years to catch up, Congress told. Report says satellites can be used as bombers and atomic explosions can be effective in outer space.

by Paul Means

WASHINGTON—The "Space Hand- ok" drawn up by RAND Corp. as a yman's guide is likely to find use also a blueprint for an 86th Congress xious to expand and speed up merica's space effort.

The document, released by the ouse Select Committee on Astro- utics and Space Exploration, en- sions attempts at landings on the moon, enus and Mars, and manned satellites orbit around the earth within the xt five years—using modifications of esent missile hardware.

It flatly disagrees with published inions of other experts and declares at satellites can be used as bomb- g platforms and that atomic bombs n be effective in airless outer space.

In the last, busy week of its exist- ce, before being replaced in the new ongress by a Standing Committee on ace and Astronautics, the select oup took two other actions under- ing the urgency of the picture.

It issued a final report saying among her things that the Soviet space lead pears to be from 12 to 18 months— d that it will take the U.S. five years catch up.

And it released a statement by hairman John W. McCormack (D- ass.) warning that "we can't afford have a Pearl Harbor in outer ace . . ."

- **Definitive work**—The RAND re- rt, which the Committee will send the nation's high schools and in- ested educational institutions, is one the most definitive treatises on space chnology and applications yet to ap- ar in lay language.

The 225-page document breaks wn space technology into 17 areas, th extensive studies of space environ- ent, trajectories and orbits, vehicles, opulsion and propellants, guidance, mmunication, observation, landing d recovery, space stations and extraterrestrial bases, and the effects of nuclear weapons in space.

It also applies present technology to the problems of orbiting and instrumenting observation, meteorological, navigation, communication and bombing satellites. It attempts to define the immediate possibilities of scientific space exploration.

- **Hardware exists**—By modifying present missile hardware, the report asserts, the U.S. can orbit satellite payloads of 10,000 pounds at 300-mile altitudes, or 2,500-pound payloads at 22,500-mile altitudes.

It says the same hardware can also land, intact, 1,000 pounds of instruments on the Moon, Venus and Mars, probe the atmosphere of Jupiter with the same payload and place a manned satellite around the earth, recoverable after a few days of flight.

Present hardware requires "additional work of a very substantial nature, the report warns, but "with diligence and reasonable luck, the overall rocket machinery necessary to attempt any of these flights could be available in a few years—probably less than five."

Within the next five years, new engine developments "should" allow us to "look forward to the day when the payloads listed above will be five to 10 times greater," the report said.

RAND'S handbook asserts that a bomb shot from behind a 350-mile-high satellite with a velocity of 1,000 feet per second—the approximate speed of a 75-mm field gun's shell—will cover a distance of 6,300 miles.

It claims that guidance under these conditions would be no more difficult than that with the surface-launched ICBM, except that exact location of the satellite would be necessary.

The advantage of satellite-bombers, according to the report, is that they could be launched under favorable conditions long before they are needed.

Multi-megaton nuclear bombs which produce sufficient radiation to kill a man can be used effectively against manned space vehicles over long distances, the report states. Even though the effects of an atomic blast are almost neutralized in vacuum-approaching space, it says, the radiation would travel farther than in the dense lower atmosphere.

Other information revealed in the report:

- The Russian 1120 pound *Sputnik II* had a total orbiting weight (including final stage rocket) of from 4.4 to 6.6 tons.
- The Russians will soon announce a successful manned-rocket flight.
- A fairly good Russian guidance system is indicated by the slight deviation in perigees (from 139.5 to 141.3 miles) of *Sputniks* I through III.
- The major Soviet satellite launching site is on the Kyzl Kum Desert, 248 miles southeast of the Aral Sea.

The Committee's final report states that "according to the best available estimates it will take the United States 12 to 18 months to do what the Soviet Union is doing now."

Moreover, according to the Committee, it will take the United States "at least five years to catch up in the sense of doing equivalent things in space at about the same time."

Chairman McCormack pointed to the recent Soviet cosmic rocket as a symbol of the urgency of maintaining a strong and consistent effort in space research and exploration.

The report's major criticism of present space programs is that decisions are based on short-run budget pressures.

"To be effective, the American space program must be long-range, flexible and continuous, with special emphasis on research," the report declares.

The Soviet Union, according to the report, boosted its scientific research outlay by 15 per cent. In view of its present space lead, the U.S., according to the report, "cannot afford to do less."

Other shackles holding down the nation's space program, according to the report, are undue security restrictions, lack of scientific and technical cooperation among the nations of the free world, and science education.

McDonnell Gets *Mercury* Award

by Clarke Newlon

WASHINGTON—"The conquest of space is such a fantastic, gorgeous and colossal subject that it's hard to know where to begin." The words were those of President James S. McDonnell of the McDonnell Aircraft Corporation.

Actually he knew very well where to begin. First, by creating a corps of design engineers comparable to any in the industry; second, by enlisting the cooperation of top people in top industries in the allied field; third by dumping a third of a million dollars into the project before bids were solicited in December. "We started last Spring," says McDonnell, "and hit the deck running."

The result was that when technical appraisers from NASA's Langley Research Center and the Air Force came to award the first contract for *Project Mercury*—placing the first man in space—it went to the comparatively small (20,000 employees, among them 5,000 engineers) McDonnell company instead of one of the industrial giants among those 12 companies which bid.

In making the award announcement, Dr. T. Keith Glennan, NASA Administrator, said that McDonnell's proposal was accepted after a careful assessment of the technical value of the proposals, facilities, experience and other qualifications.

• **$15 million contract**—The initial contract will be for a dozen satellite capsules (with equipment) and their subsystems—for $15 million. This will probably be only a starter if the first few experiments prove successful. And it will, of course, include none of the cost of the booster, probably the *Atlas*, or for any of the ground handling equipment.

"This first capsule," McDonnell told m/r after the award, "will be what has become known as a conventional satellite." First passengers in the first few experimental flights will be animals, he said, with finally a man to be placed in space. The program, McDonnell said, will be "greatly accelerated" although he did not expect the first man up before at least two years. Who this first man will be, he said, will be NASA's problem, not McDonnell's.

The capsule (m/r, Nov. 10, p. 13) will be equipped for either water or earth landing, will have both drogue and landing 'chutes, a very sophisticated communications and control system, with the pilot having full command.

Collins Radio Co. will develop complete electronic instrumentation. Minneapolis-Honeywell will supply stabilizing and control systems.

It will have a high aerodynamic drag, non-lifting in type, designed to withstand any known combination of acceleration, heat loads and aerodynamic forces during boost or reentry. It will have a blunt leading face covered with a heat shield.

A closed loop control system consisting of an attitude sensor with reaction controls will maintain orbital attitude and establish the angle for retro-firing, reentry or abort.

Retrorockets for reentry can be fired by the pilot or from the ground. Emergency systems will allow escape in case of misfiring. Ground and booster equipment will determine the original orbit; both ground and capsule equipment will guide it thereafter. Communications equipment will include two-way voice radio, a command receiver and tracking telemetry. The orbit will be nearly circular, 100 to 150 miles up with a 24-hour lifetime.

NASA's project chief for *Mercury* will be Robert G. Gilruth. McDonnell's engineering manager of *Mercury* will be John F. Yardley, with E. F. Peters and G. F. Weber assisting for capsule design and equipment and electronics, respectively. Keeping a watchful eye over all will be L. M. "Mike" Weeks, chief of preliminary design engineering and Ray Tepping, assistant—and Jim McDonnell.

Congress Sees Urgency in Space-Missile Goals

WASHINGTON—The opening week of the 86th Congress was similar in mood to the post-*Sputnik* high-temperature sessions early last year. The heat generator this time was *Lunik;* heat conductor: next year's elections.

Ascent of Russia's man-made planet on the eve of Congress' opening set off demands for new approaches, more money and an investigation of space-defense policies. Recriminations against the Administration's attitude on this hot issue will get louder as the powerful Democratic majority goes into high gear.

The new chairman of the House Committee on Science and Astronautics said he would call for an immediate investigation to determine "where we stand" in the space race. Chairman Overton Brooks (D-La.) said that while he was not "being critical of anyone," the nation's space program must be conducted on an urgent basis.

• **Change in signals**—Proponents of bills which had been given slim chance of squeaking through this year were suddenly optimistic. Example: th measure introduced by Sen. Hubert H Humphrey (D-Minn.) to create a De partment of Science. Feeling had bee that last year's crop of new agenci and councils should be given a chanc to operate a year or two before an other agency was set up or any chang were made. Supporters claim *Lun* may have given their cause a decisiv shot in the arm.

Foes of the science departme plan had argued that establishment the new Federal Council for Scienc and Technology made an addition agency unnecessary. But supporte pointed out that while the council aim is to "promote closer cooperatio among Federal agencies" in researc areas, it has no policy-making au thority.

• **Crash program urged**—Sen Henry M. Jackson (D-Wash.) urged crash program to snatch space leade ship from the Russians. He charge the Administration with a "business usual" approach in a situation callin for "dramatic" action.

Jackson, a member of the powerf Armed Services Committee, score penny-pinching in defense plannin "We are going to have to spend mo money," he declared. "There is no su stitute for it."

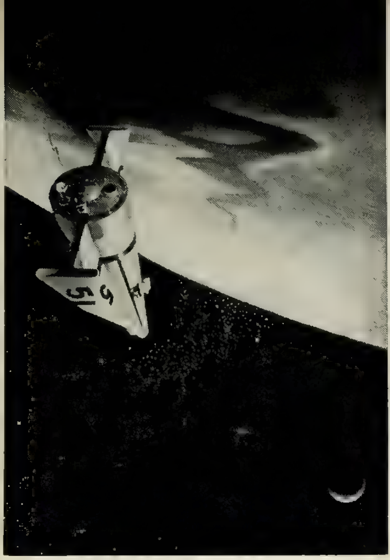
Other Congressional critics hav been similarly vocal about what the call the Administration's mania f putting economy above defense need They will look for inadequacies in th proposed $41-billion defense budg with fine-toothed combs.

Other proposed defense measur boosted by *Lunik's* impact include th bill by Sen. Leverett Saltonstall (R Mass.) calling for major military pr curement changes involving weapo system management, easing of reneg tiation inequities and liberalization patent rights in the NASA Act.

About the Cover

Space means different things to different people and to these newsmen watching the blast-off at Cape Canaveral it means the tense, breathless moment when the countdown voice reaches the climax—"three, two, one."

There is the second of silence, the whoosh of flame and the unbelievable beauty of the slim, fire-tipped missile cleaving the black sky into space. This week's cover picture shows newsmen on the bleachers one mile from the firing pad at that moment. Above them newsreel cameramen are similarly poised, equally tense, muttering to each other the warning: "Don't move. Don't move. You'll shake the cameras."



Lockheed Space Station Interesting U.S. Agencies

Satellite laboratory could be in operation in 10 years; Cost estimate put at $2.163 billion.

by **Norman L. Baker**

WASHINGTON—A Lockheed pro- sal to place a "permanent" manned tellite laboratory in operation within years reportedly is interesting gov- nment agencies.

Estimated cost of the station is .163 billion. This includes develop- ent, construction, and launching, but es not allow for major breakthroughs the state of the art.

The necessary engineering know- w has been developed and hardware either available or under develop- ent for an immediate start on a seri- s, coordinated program to put the oratory in orbit, Lockheed scientists y.

In a highly detailed report, based long months of study, Saunders B. amer and Richard A. Byers of Lock- ed's Missile Systems Division pro- se a launching system, satellite ve- les and operational procedures in e with established engineering tech- ques. The report was presented be- e the American Astronautical So- ty's fifth annual meeting.

Unlike many previous proposals, report makes no reference to plans designs far from the threshold of uisition. For example, throughout entire operation—from launch and embly of prefabricated components orbit to the transfer of personnel the completed station—the men uld be sheltered from the space ironment in cabins with simulated th conditions.

No clumsy, asphyxiating space suits h impracticable magnetic shoes are gested for "protecting" the satel- 's assembly and staff personnel. Kra- r and Byers say it is time for space ineers to forget such "science fic- n" schemes except for emergency ipment.

The outstanding feature of the system, assuring maximum personnel protection and working flexibility, is the "astrotug," a vehicle employed in the assembly of the space station. The cylindrical prepackaged compartments to be joined later to form the satellite would be launched separately and guided to a rendezvous point on the same orbit. "Astrotugs," with a crew of three, would then be used to round up, assemble, and activate the space station.

The men who assemble and staff the space station would travel into orbit aboard the "astrotugs" and earth-space taxis (re-entry vehicles). Return to orbit would be made aboard the re-entry vehicles. All components would be launched in the nose of a basic three-stage rocket with a recoverable first stage.

• **Concept philosophy**—The multi-manned satellite laboratory and space embarkation exploration platform could not be launched into orbit by a single vehicle using current propulsion systems. Hence, Kramer and Byers propose that the station be sent up in segments for attachment and integration later. Each section would be a self-sufficient unit. The first one would carry provisions to support several men for a number of months.

The sections would be prefabricated on the ground. Each would be a sealed compartment, with coupling devices and air locks at both ends. All would be self-sufficient to some extent, and most would be pressurized before going into orbit.

A number of sections would be launched and bunched together by ground control before men were placed in the orbit to complete the assembly.

Following the first group of sections, a small, multi-manned maneuverable satellite, the "astrotug," would be guided to the cluster. Operating like a railroad switch engine, the "astrotug" would collect and join the sections. It would carry supplies to maintain three men for seven days, time needed to assemble the first components.

A separate re-entry vehicle would follow the first tug into orbit to stand by while the initial group completes its task. Air locks on both tug and re-entry vehicle would permit transfer of men and materials. Each subsequent group of compartments and crew sent into orbit would have at least one re-entry vehicle placed into orbit with it.

• **Orbit establishment**—To insure maximum life of the satellite free from drag forces of the atmosphere, an orbit 500 miles out, below the radiation belt, is suggested as the minimum altitude.

The first, or pilot, compartment would carry a transponder to identify itself as the homing target. In addition to establishing a coordinate reference for positioning data for the other compartments, this unit would be equipped with ranging radar for determining the spacing of the compartments in orbit, a nitrogen propulsion system for controlling its attitude and orbit, and a computer-memory unit for computing corrections to maintain proper spacing of the compartments.

After the compartments went into orbit, a ground-controlled thrust maneuver would correct the actual orbit to coincide with the standard orbit.

With the pilot compartment established in orbit, three compartments would be launched in a salvo. The third stage of each rocket would home in on the pilot compartment for proper positioning. Collisions would be avoided by choosing a closing point one or two miles from the pilot compartment.

Next, the first re-entry and "astrotug" vehicles would be sent aloft. The homing technique would be repeated with the manned vehicles free to maneuver after they reach the proper spacing.

The re-entry vehicle would be housed in the final stage of the three-stage rocket and fired into the 500-mile orbit in 6-10 minutes. During this phase of the operation the pilot would have no control except as a monitor or a back-up to the programmed flight path. In case of a malfunction, the ground control operator could override and take control of the automatic system.

The return trip is estimated at two to four hours, based on the "g" limitations of personnel and the maximum temperatures which the structure could endure. Re-entry attitude would be critical and Kramer and Byers doubt that an inertial system can retain its reference axes to the degree necessary for re-entry over the period it will be in orbit.

They propose a satellite control reference platform that would establish coordinates with respect to the local vertical and orbital plane and feed its output continuously to the caged stable platform in an autopilot. Integrating accelerometers would be fixed to the vehicle structure to measure and integrate accelerations along each of the three vehicle axes.

- **Re-entry maneuver**—In returning to earth, retro-thrust applied to the vehicle would enable it to descend on transfer ellipse. The control platform would give continuous attitude, altitude, and velocity data to the pilot display and autopilot stable platform.

Turbojets started as the vehicle entered the subsonic would supply thrust for subsonic flight to rendezvous with a mother airplane. The pilot could override the automatic control system for landing aboard the mother airplane or for emergency landing.

- **"Astrotug" operation**—In the course of the "astrotug's" operation as the assembly vehicle, its crew would be charged with locating, identifying, capturing, and returning to the assembly point each of the 23 compartments in the sequence required for assembly.

Kramer and Byers estimate that maximum dispersion, by the time the first "astrotug" arrived, would be held down to a few miles.

With the pilot compartment fixing the position of station assembly, the "astrotug" would acquire the second compartment on its radar or infrared search equipment. Using its navigation computer, the "astrotug" would travel to the compartment, return it to the assembly point, and join it to the first compartment. The coded transponder aboard each compartment would provide identification for order of assembly.

- **Re-entry vehicle design**—The re-entry vehicle would be an outgrowth of an advanced delta-winged airplane combining the features of a hypersonic glider and a subsonic powered aircraft.

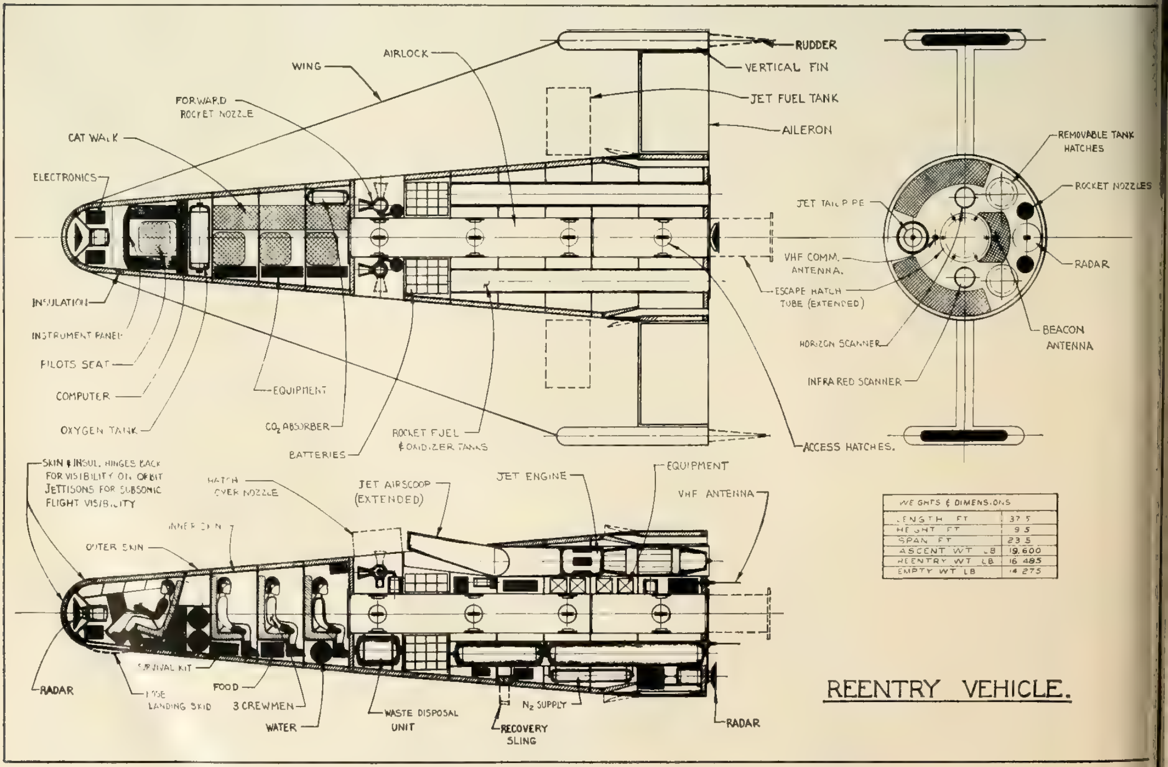
Pilot observation would be through a windshield protected during re-entry by hinged thermal doors. A full circular horizon scanner would provide optical orientation while in orbit.

Power for orbit maneuvering would be provided by "throttleable" rocket engines. Using fluorine and hydrazine as propellants, the engines would have a thrust of 200 pounds.

Two solid propellant rockets with a total thrust of 18,000 pounds and a burning time of 20 seconds would initiate re-entry. For flexibility in the recovery operation, the vehicle would be equipped with a jet engine system yielding a 100-mile range.

Basic re-entry features of the system are predicated on the establish-

(*Continued on page 32*)



WEIGHTS & DIMENSIONS	
LENGTH FT	37 5
HEIGHT FT	9 5
SPAN FT	23 5
ASCENT WT LB	19,600
REENTRY WT LB	16 485
EMPTY WT LB	14 275

REENTRY VEHICLE for Lockheed-proposed space station could carry crew of four.

astronautics in the news . . .

ANORAMIC VIEW of weather
nditions is shown in this com-
osite of five photographs taken
a camera rocket fired from
allops Island, Va. Photographs
ken from an altitude of 86
iles, show an area of 1000
iles extending, left, from Nova
otia to hundreds of miles
uth of Bermuda. Cameras op-
ated at shutter speeds of
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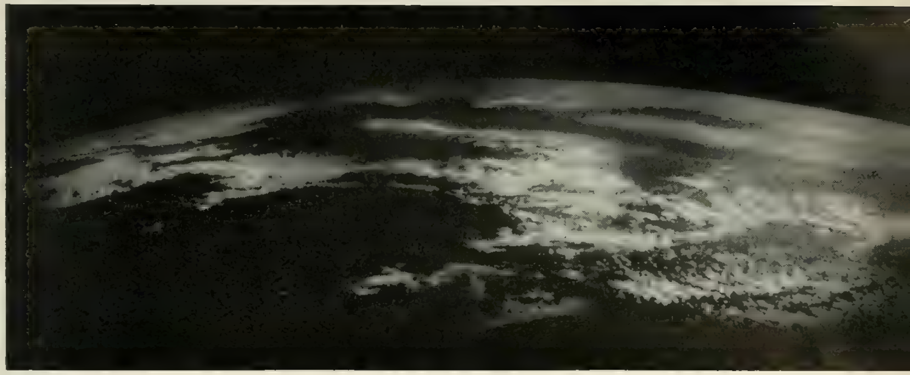
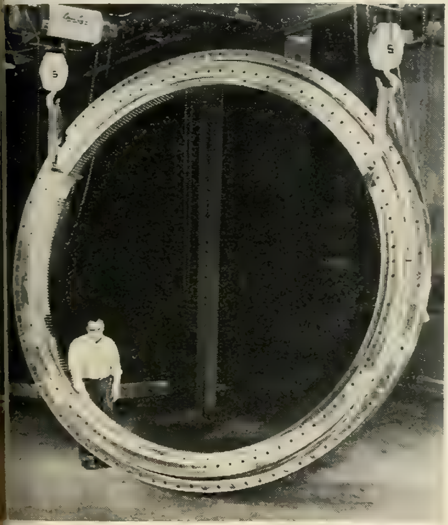
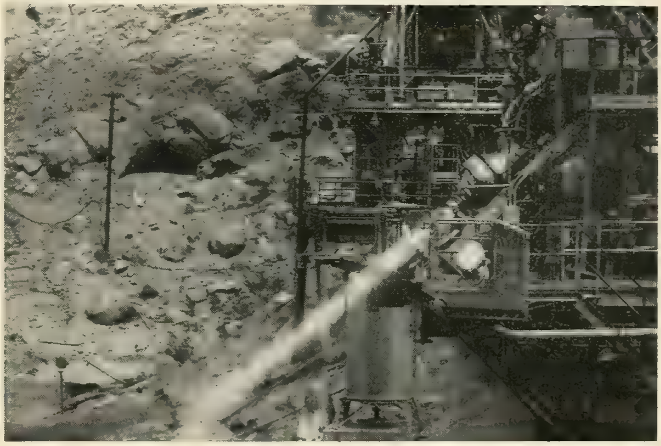
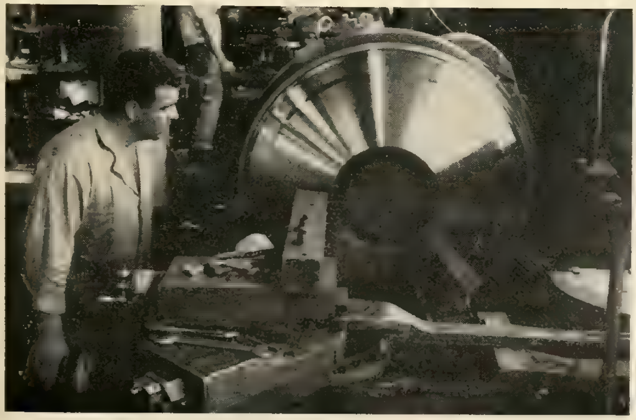




THIS BALL bearing made by Kaydon Engineering Corp. is 13 feet 9 inches in diameter. Designed for the *Nike-Zeus* radar system, it will hold weight of one-million pounds.

FIRST ROCKET engine nozzle for the *Kiwi-A (Project Rover)* atomic engine system undergoes static firing test at Rocketdyne with conventional propellants before being shipped to the Los Alamos Scientific Laboratory.

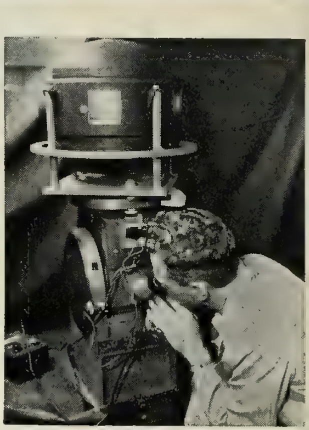




Polaris **ROCKET MOTOR** casing part being machined by Diversey Engineering Co. for Aerojet-General Corp., propulsion system prime contractor for the fleet ballistic missile. Of large diameter by present-day standards, it still is not big compared to some of the solid propellant motors now in the works, such as *Minuteman* where Aerojet shares propulsion development position with Thiokol Chemical, Allegany Ballistics Lab. and Grand Central Rocket Co. Parts are machined from very high-strength steel alloys and must be finished to extremely high tolerances.

Gyro Drift Demanding New Measurement Techniques

by **Ralph Hookway**
Electronics Department,
The Martin Company



GYRO MUST be mounted on rigid and precise turntable.

BALTIMORE—With the newer long-range missiles requiring more exacting drift rates for gyros in inertial systems, industry today is faced with the task of providing new measurement techniques to keep pace with developments.

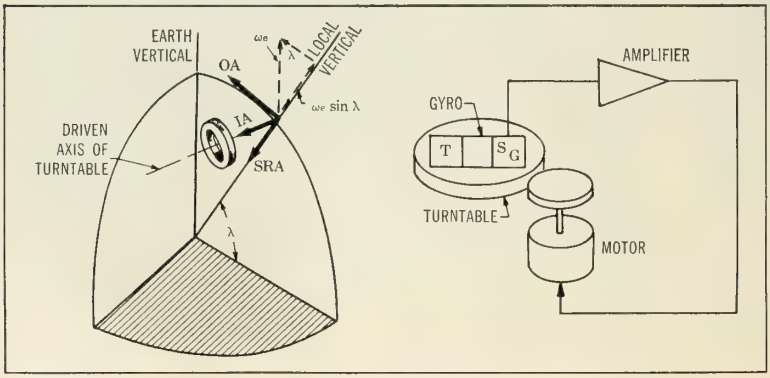
In pre-missile days when gyros were widely used in short-range blind-flying devices, they could drift as much as five degrees an hour and still do their job satisfactorily. But today' newer missiles, demanding a rate o less than 0.05 degrees an hour, brin new requirement standards.

This article will summarize dri measuring techniques for systems use in the TM-76 *Mace* which has a fairl long flight time in an acceleration e vironment of essentially 1g. Ballisti missile systems which experience hig accelerations for short flight-time p riods, will not be considered.

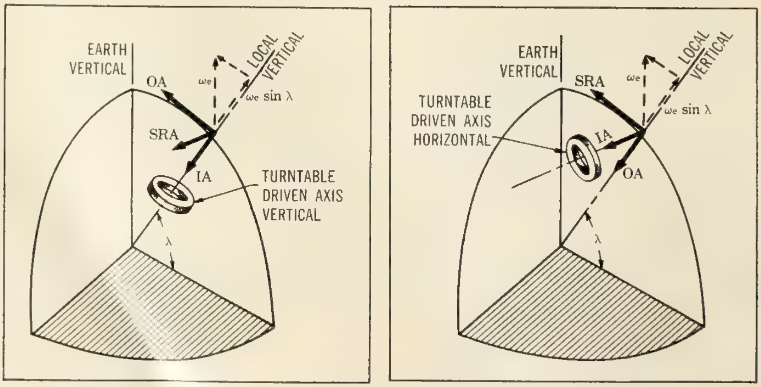
- **Drift causes**—By definition, dri rate is that angular velocity about th input axis (with respect to inerti space) which is necessary to keep th gyro output signal constant (near zer when no signal current is applied the torquer. It results from design lin itations and imperfections in manufa ture, such as very small, residual im balances which produce a torque whic in turn, generates a drift rate.

Stray torques are also introduc by the electrical lead-ins to the flo bearing friction, and the self-induc magnetic fields at the pick-off a torquer. In typical inertial instrume the torque producing the characteris drift rate is very small. For exampl a gyro with an angular momentum 10^5 gr-cm^2/sec when subjected to torque of only 0.02 gr-cm^2/sec^2 d plays a drift rate of 0.05 deg/hr. a 1 cm arm, this torque is produc by a mass of only 2.47 x 10^{-5} grams

Since the torques are so small a can be measured only with the gy completely assembled, a technique h been developed which, in effect, us the assembled gyro to test itself. Stat



TURNTABLE-MOUNTED gyro is used to measure total drift rate U_1 in *Mace*.



DIAGRAMS 2 (left) and 3 (right) determine drift rates U_2 and U_3.

New electronics frontiers

Advanced systems research, to meet the demands of complex modern weapons systems, is among the many new activities that attract engineers and scientists to IBM. This research encompasses over-all planning of methods for the detection of flying objects . . . feasibility studies of guidance, detection and defensive systems . . . specification of radically new equipment for terrestrial and stellar navigational problems. Academic studies of logistics, operations research, information and communications theory are also part of this new research at our Kingston facility.

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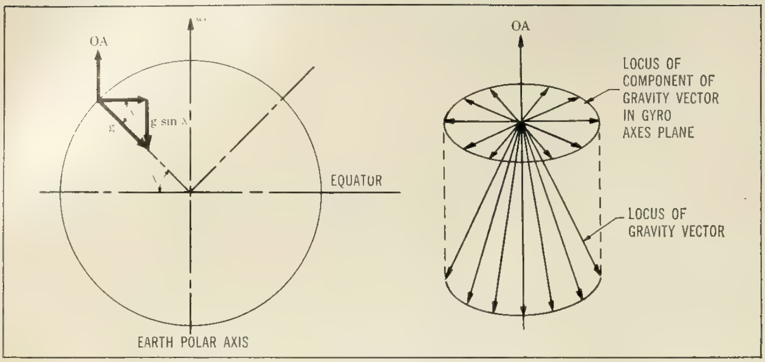
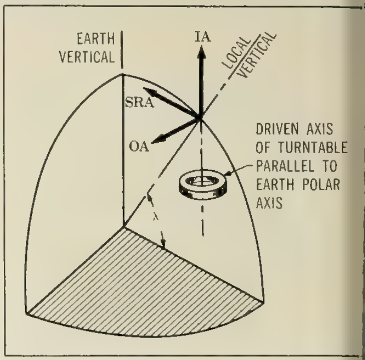


LOCUS OF GRAVITY vector relative to gyro axes.



ALINEMENT of gyro axes in *Mac*

inputs are earth's rotation and gravitational field.

Total drift rate includes a gravity-sensitive component (gravity-caused deflections of the gyro structure which introduce stray torques) and a non-gravity-sensitive component which accounts for all other torques. To fix the maximum value of the gravity-sensitive component (important in the calibration of guidance systems), a method must be devised to separate the non-g-sensitive component from the total measured drift rate.

• **Test formula**—One technique is to measure the two components separately, apply a correction to remove apparent drift due to the vertical component of earth rate at the latitude of the test site, and then calculate the maximum gravity-sensitive drift rate from the relation:

$(Ug)^2 \max = (U_1 - U_3)^2 + (U_2 - U_3 - W_e \sin \lambda)^2$ (1) where $(Ug) \max$ = maximum gravity-sensitive drift rate

U_1 = total drift rate measured with SRA vertical and OA oriented north-south

U_2 = total drift rate measured with IA vertical and OA oriented north-south

U_3 = non-g-sensitive component measured with OA vertical and SRA oriented north-south

W_e = earth's angular rate

λ = latitude of the test site.

From the geometry of U_1, U_2, U_3, (Diagrams 2 and 3), some requirements of test accessories can be deduced. The gyro must be mounted on a very rigid and precisely built turntable (see photo). High-precision optics are needed to measure table rotation to within a few seconds of arc. Since tests usually take several hours, there should be a means of simultaneously recording table position and accurate time base.

Total drift rate U_1 is measured by mounting the gyro on the turntable as shown in Diagram 1. The input axis is parallel to the driven axis of the table, which is horizontal and pointed east-west. When rotated about its output (turntable) axis so that the spin reference axis is vertical, the gyro does not see any component of earth's rate. A servo loop is then formed by using the gyro pickoff signal to drive the turntable as shown in the right of Diagram 1.

The table is driven at a rate which just keeps the gyro output nulled. This rate is a direct measure of gyro drift rate for the orientation under test.

Total drift rate U_2 is determined with the gyro mounted on the same turntable with turntable and gyro input axes coinciding parallel to the local vertical as shown in Diagram 2. As before, OA is aligned north-south. In this orientation, there is an apparent drift rate arising from the vertical component of W_e which lies along the gyro input axis in addition to the drift rate resulting from structural deflections. This component of earth rate has the magnitude of:

$W_{ev} = W_e$ sin

This relation shows that the better the gyro the more accurately the latitude of the test site must be known.

• **Exact location**—To keep errors small relative to the drift rates being measured, the test site location should be known so accurately that the vertical component of earth rate is no greater than about 1/10 of the expected drift rates. The following shows typical values of the survey accuracies required for various classes of gyros:

Autopilot directional gyros:

Typical Drift Rate	Allowable Site Error
1 to 10 deg/hr	0.5° to 5°

Directional gyros for polar navigation:

Typical Drift Rate	Allowable Site Error
0.1 to 1	3 min to 30 min

Inertial navigator gyros:

Typical Drift Rate	Allowable Site Err
0.001 to .1	2 sec to 3 mi

It is now possible to define U_3 the drift rate measured by orientir the gyro so that its OA is vertical, SR horizontal and pointed north-south. I and the driven axis of the test turntab are horizontal, pointing east-west shown in Diagram 3. The local gravi vector lies along the OA so that gravity-induced torques are applie Nor is there a component of earth ra to account for.

From this testing procedure, get the maximum drift rate to expected from a gyro in an lg gravit tional field regardless of its orientatio While a measure of gyro quality, t data is not directly useful in p launch adjustment of certain inert guidance systems, since it does not d plicate the time history of the relati between the gyro axes and the lo vertical which will occur in flight.

• **Geometric system**—The *Mace* ertial system is of the geometric ty however. Here the gyro reference fixed in inertial space at the laun point vertical while acceleromet track the local vertical throughout flight to indicate the earth central an between launch point and present p tion. Distance traveled over the surf of the earth is easily obtained.

In general, orientation of the lo gravity vector relative to the gyro a varies during flight. Since the g drift rate varies with the orientation gravity, to achieve the utmost accur from the guidance system the d measured should be corrected for s sitivity of the gyro to gravity orien tion. Gyro coefficients to be used data inserts in the guidance system obtained by tumbling tests.

The same type of test table (pho

s used. One of the gyro axes (and the able axis of rotation), however, is ligned parallel to the polar axis of the arth. Under these conditions the locus f the gravity vector relative to the yro axes is as shown in Diagram 4. wo minor effects, which can be nelected, are the 365-day cycle of the arth about the sun, and the change f earth's gravity due to the motion f the moon in its 29-day orbit.

The gyro axes can be aligned as own in Diagram 5 and the gyro pickff signal can be used to drive the table nd hence the gyro pickoff to null. This rocedure fixes the gyro in inertial ace while a component of the gravity ector rotates in the plane defined by e output and spin axes.

Results of this test can indicate the erformance of a geometric inertial idance system. Total angular motion ported by the gyro in a given time eriod is compared with the actual gular motion of the earth in the same me. The difference is due to the drift te of the gyro, which is reflected in stem performance at the rate of 1 in of difference after an hour long st run for 1 mi of error in navigation ter one hour's flying.

Another type of tumbling test can performed with the gyro output axis rallel to the earth's polar axis and e test turntable axis. The gyro is aged" by using the signal pickoff to ive the gyro torquer (after proper plification). The test table is rotated some multiple of earth rate, but this tation is not seen by the gyro since component of it appears along the ro input axis. Recording the torquer rrent as the orientation of gravity ries varies gives a measure of gyro ift.

glin Telemetering ontract is for $500,000

PRINCETON, N.J.—A contract of re than $500,000 for supplying ee telemetering ground-station sysns for the Eglin Gulf Test Range, a., has been awarded by ITT labatories to Applied Science Corp. of nceton.

The project calls for a 300-mile ctronic "scoreboard" for testing miss and aircraft, including *Bomarc*. e ground station equipment will be d at three separate range sites for eiving, reducing and recording teletered flight-test data.

Each systm will contain FM/FM, M and PW equipment, simultausly handling data signals from ee aircraft or missiles and from three nes. Each aircraft or missile will able to transmit to each site four tinuous data channels and up to 90 channels of time-division commutated data. Each drone will be able to transmit to each site four continuous data channels.

A central control section will provide flexible patching facilities for programming ground station equipment allocation to meet the requirements of the test range.

Thermoelectric Generators Have 6% Efficiency

ST. PAUL, MINN.—Thermoelectric generators with an operating efficiency of about six per cent have been developed by Minnesota Mining and Manufacturing Co. The generators use heat applied to semi-conducting materials.

The company has been in pilot plant production of semi-conductor elements and sub-assemblies for more than a year, a spokesman said, and now has adapted the material to complete, operative generators.

One of the generators is a five-watt unit about the size of a quart fruit jar, which reportedly operates at six per cent efficiency and is intended for use with an isotope heat source. This unit is designed to be cooled by air.

Similar units are being designed for cooling with water or by radiation, the company said. Additional generator types are to be built this year.

Standard Navigation Aids Could Guide Space Travel

COLUMBUS—Even though chances of hitting a planet with a ballistic shot are slim, a manned space vehicle capable of in-flight corrections could reach a planet with existing navigation equipment.

Arthur S. Cosler Jr., executive director of Ohio State University's Mapping and Charting Research Laboratory, who made the statement, emphasized that the vehicle would have to be powerful enough to carry such instrumentation.

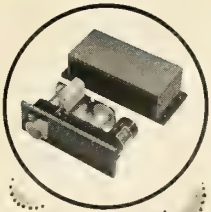
The University is conducting research on navigation techniques for interplanetary space flight on an Air Force contract granted to its research foundation. The objective of the project is to examine all potential sources of space navigation information.

Some of the possibilities being considered include: taking bearings on planets; sending out radar signals from an earth-fixed station or from a satellite; using charts of the intensities of electron or ion clouds in space, or maps of magnetic field strength and direction in space. One conclusion already reached is that a space vehicle would need to alter course during flight to

Beattie-Coleman built 100 g's into the MPR-13 Programer

Resistance to high shock loads is just one of the amazing pluses of the Beattie-Coleman MPR-13 punched Mylar tape Programer. The MPR-13 is the accepted standard for multi-channel programming because of its compatibility with most missile guidance systems . . . and performs with an accuracy of one part in 50,000 under these high "g" loads! Programs can be initiated or altered in a few minutes with millisecond precision for either repeat cycling or random operations.

The rugged Beattie-Coleman MPR-13 Programer weighs 3 lbs. 10 ounces, is 2"x3"x6". More information is available on request.



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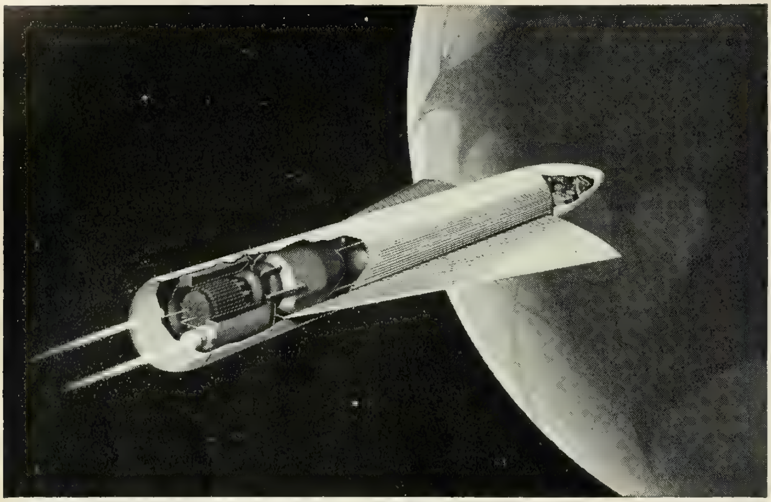
for the conquest of space



ROCKETDYNE ENGINEERS HAVE MADE MORE THAN 50 TRIPS TO THE NEIGHBORING PLANETS

Through the ship's viewing port looms a breathtaking sight—a gigantic red crescent spanning some 30° of deep black sky. A television camera, passenger on this strange new chariot, stares intently at a sight never before seen by man and beams home to Earth his first crude view of the planet Mars.

From dream to drafting board

Less than a decade will pass before this age-old dream of man is realized. Bold steps toward such an exploration of Space are underway now. An experimental ion rocket engine will soon be placed in operation at Rocketdyne's Propulsion Field Laboratory in the Santa Susana mountains. From this research tool will come design data for the efficient, low-thrust freight engines for Outer Space. These engines will be capable of operating for months at a time, and will make possible extended reconnaissance of the Solar System and detailed studies of the phenomena of Space.

But what of the journey itself?

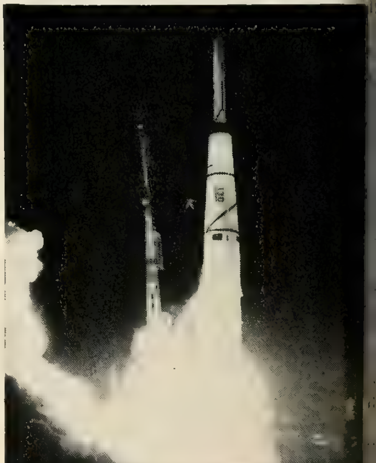
Rocketdyne engineers have made more than 50 trips to the neighboring planets on huge computer machines. In these paper trips, they have studied the gravitational effects of as many as seven planets at a time. By watching closely the effects of such forces on their low-thrust ion vehicle they determined thrust programs to reach various planetary objectives. They showed the trip to Mars could be made with thrust to vehicle-weight ratios as low as 1 to 10,000.

Testing in Space conditions

Rocketdyne has been at work on ion rocket engines since 1955. While many difficult design problems yet need to be solved, extensive new facilities and three years of exhaustive studies are being applied to the job. Rocketdyne scientists will operate their experimental ion engine in simulated space conditions to unlock important answers to thrust chamber design, power conversion systems, nuclear heat sources, and propellants.

Hardware for defense and science

Today the operating hardware in the field of high-thrust rocket engines is designed and built by Rocketdyne: propulsion systems for the Air Force's Atlas and Thor, and the Army's Redstone and Jupiter . . . and for scientific missions such as the Explorer satellites and the NASA space probes conducted by the Air Force and Army. Based on this unequalled experience, Rocketdyne is already probing far into the future. Engineers are already at work on the next and succeeding generations of high-thrust rockets, and high-specific-impulse engines to supplement chemical rocket performance.



PROBING TOWARD THE PLANETS
Heaved bodily into Space by the Rocketdyne-powered Thor first stage, the Pioneer starts on its 80,000 mile sortie toward the moon.

FIRST WITH POWER
FOR OUTER SPACE

ROCKETDYNE

A DIVISION OF NORTH AMERICAN AVIATION, INC.

rrect for navigational and ballistic
rors.

• **Loss unlikely**—Cosler said there
as little chance of a manned rocket
coming lost in outer space even with
e standard navigation aids now avail-
le, provided the vehicle could man-
e to carry them all. The navigation
ds are necessary, he explained, be-
use a prime difficulty in intercepting
e moon or a planet with a ballistic
ot is man's inexact knowledge about
e true distances in space. He said
lculations of interplanetary distance
e based on a distance from the earth
the sun which carries a margin of
ror of several thousand miles.
On another point, Cosler said that
ch more must be learned about how
an will function in space before sci-
tists can decide what navigation
uipment must be automatic.

mphenol and Borg Firms erge Electronics Output

CHICAGO—Two major Midwestern
ctronics firms, Amphenol Electronics
rp. and the George W. Borg Corp.,
ve merged into Amphenol/Borg Elec-
nics Corp., with combined assets of
re than $37 million.
Arthur J. Schmitt, Amphenol's pres-
nt, is chairman of the board and
esident of the new company and
orge W. Borg, chairman of the Wis-
nsin firm, is chairman of the execu-
e committee.
The consolidation was approved by
ckholders of both companies in
eetings held Dec. 30. It was effective
c. 31.
The merged companies, with head-
arters here, will have total floor
ace of a little more than 1 million
uare feet when Amphenol's new Chi-
go plant is finished. The figure ex-
udes divisional plants in Connecticut
d California.
Amphenol is a major supplier of
nnectors, cables and other electronic
mponents for missiles. Borg pro-
ces precision potentiometers, direct
ading counting dials and electronic
struments.

CA Adds Space For Its rowing Missile Business

Radio Corporation of America has
sed a two-story brick building at
oydon, Pa., to provide space for its
panding military business.
The new plant, containing 74,000
uare feet of floor space, is situated
about seven acres of land 20 miles
northeast of central Philadelphia.

The new facility, combining one- and two-story construction, will be under the jurisdiction of RCA's Missile and Surface Radar Dept., Moorestown, N.J., and will provide supplementary space for rapidly expanding activities at that location.

missile people

Dr. Patrick Conley has been appointed manager of the Westinghouse Electric Corp.'s Air Arm Div. Dr. Conley, technical director on the Defense Products Group headquarters staff, succeeds **Dr. S. W. Herwald,** former manager of the Air Arm Division, who was recently named vice-president for research.

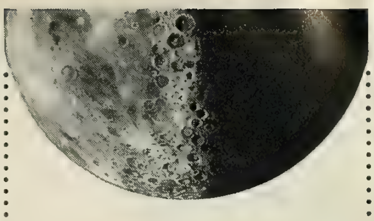
Rep. Overton Brooks (D-La.), slated to head the House Science and Astronautics Committee is known as a "progressive Southern Democrat." Long a member of the House Armed Services Committee, where he is second-ranking member, Brooks is highly respected by Defense Department officials who come to committee hearings well-prepared for his searching questions. It is expected he will leave the Armed Service Committee.

Dr. Siegfried J. Gerathewohl, authority on weightlessness and a contributor to m/r, has joined the Von Braun team at the Army Ballistic Missile Agency. He will work under **Dr. Ernst Stuhlinger,** ABMA's director of the Research Projects Laboratory. Dr. Gerathewohl left the School of Aviation Medicine where he has conducted experiments on the effects of weightlessness in space flight after coming to this country from Germany 11 years ago.

Henry E. Billingsley has been appointed director of the Office of International Cooperation of the National Aeronautics and Space Administration. He was formerly chief of the Western European Division in the Defense Department's Office of Internal Security Affairs.

George M. Bunker, president and chairman of the board of the Martin Co., has been elected to Bulova's board of directors.

Dr. Allen E. Puckett has been named a vice-president and director of the systems development laboratories of Hughes Aircraft Co. **Lawrence A. Hyland,** vice-president in charge of engineering, has been appointed vice-president in charge of systems management. **Dr. Nathan I. Hall,** vice-president and director of systems development laboratories, has been named to fill Shank's former post.



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Chemical Physicists

To make studies on propellants for ion propulsion. Experienced in electronics, atomic physics, and physical chemistry.

Physicists

Primary activities will be in the field of ion sources and high vacuum techniques. Experienced in particle accelerators, ion sources, and electronics.

Electrical Engineer

Analysis of electrical power generators, preliminary stages designs of permanent magnet, AC induction and electrostatic generators.

Please write: Mr. D. A. Jamieson, Engineering Personnel Dept., 6633 Canoga Avenue, Canoga Park, Calif.

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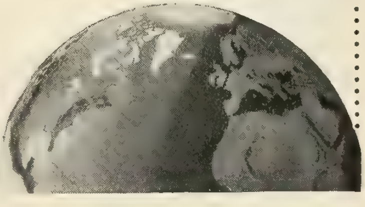
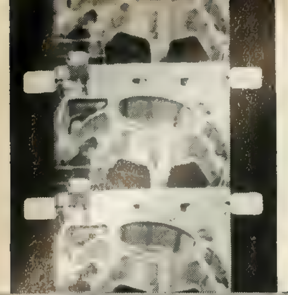
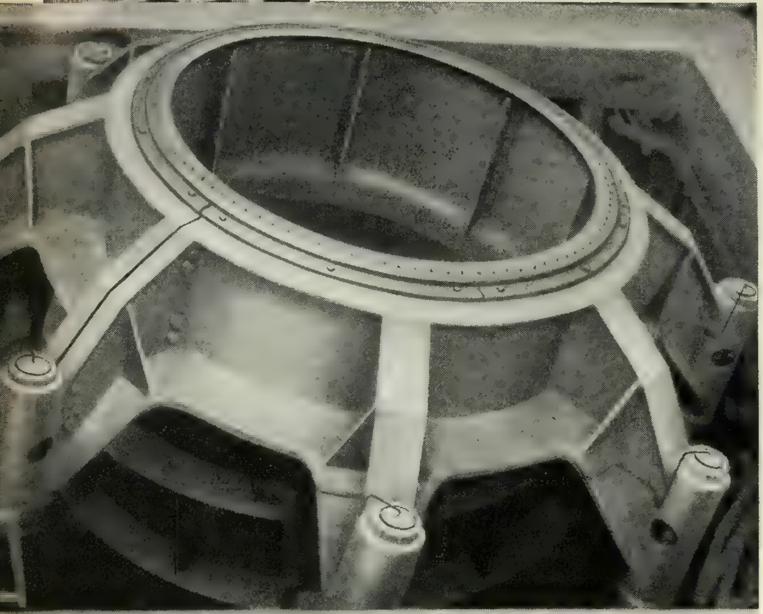
A DIVISION OF NORTH AMERICAN AVIATION, INC.
FIRST WITH POWER FOR OUTER SPACE

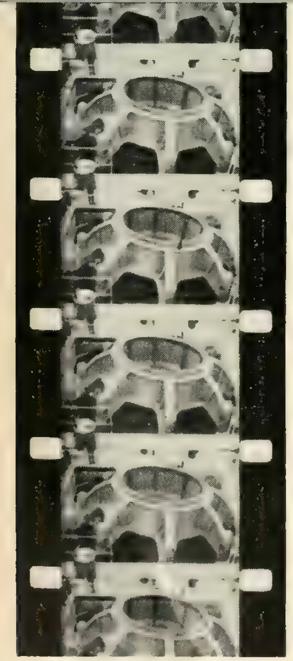




"Shaker" pitching



"Shaker" rolling



"Shaker"–Loewy's giant rocking horse–paves way for ballistic missile firing at sea

The giant ship motion simulator called "Shaker" has come to life. Designed and built by Loewy-Hydropress under prime contract with the U.S. Navy for its Fleet Ballistic Missile Program, the 40-ft.-tall rocking horse moves up and down, fore, aft and athwart under the electronic fingertips of a distant operator in a thick-walled concrete blockhouse.

"Berthed" at Cape Canaveral not more than 800 feet from the beach and nested in a 47-ft.-deep pit, "Shaker" performs all the important movements of a seagoing vessel. Sliding up and down, she imitates the vertical heave motion. Tilting port and starboard, she acts out rolling. Rocking forward and backward, she duplicates pitching. An intricate mechanism of giant gyrating joints makes these rock 'n' roll moves and their innumerable combinations possible. By proper setting, the typical behavior of an oceangoing vessel in seas ranging from calm to stormy can be recreated precisely by "Shaker."

Polaris, the Navy's Fleet Ballistic Missile, will soon be tested on "Shaker."

For creative engineering and design, research and development in your defense and industrial contracts, direct your inquiries to us at Dept. S-1.

Loewy-Hydropress Division

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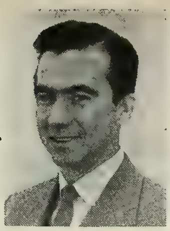
space age



by Norman L. Baker

Charting *Lunik's* orbit—The tenth "planet" of the solar system (actually a man-made planetoid or asteroid) reached its perihelion of 91.5 million miles about Jan. 14 and began its decelerating swing out and around the sun. About one million miles from the earth at its closest approach to the sun, it is slowly being overtaken by the earth at the rate of about .181 degrees a day.

After earth and *Lunik* reach conjunction (possibly sometime this month) the earth will rapidly pull ahead of the Russian probe, overtaking it again in roughly 5.43 years. Sometime in early 1964 *Lunik* will make its first close approach to the earth. Even then the distance will be far beyond the earth's gravitational attraction.

Estimated planetary data—*Lunik*—or *Mechta* (dream), as the Soviets later tagged it—left the earth with a burnout velocity of 25.7 miles per second (in relation to the sun). At its closest approach to the moon (4,660 miles), its velocity had been reduced to 20 miles per second. As the probe moved away from the earth-moon field the sun's attraction upped the velocity to 20.1 miles per second at the perihelion. By the time it reaches its aphelion of 123.25 million miles on Sept. 9, its orbital speed will be reduced to 15.1 miles per second and it will be more than 33 million miles from the earth. This will put *Lunik* within 5-6 million miles of the closest approach of Mars' orbit to the earth's orbit (Mars at that time will be tailing *Lunik* by about 145 degrees).

Moon impact attempted—There's increasing evidence that Soviet scientists attempted to send their payload into an intercept with the moon. The earliest Tass announcement of *Lunik's* estimated arrival time in the vicinity of the moon was three hours later than the actual time of arrival. The moon moves about the earth approximately one diameter every hour (orbital velocity: 2287 mph, diameter: 2160 miles)—in three hours the moon would have traveled 6861 miles.

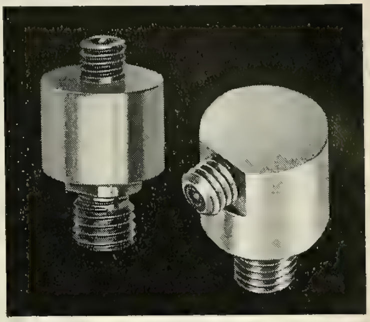
Lunik **led the aft side** of the moon by 6820 miles, indicating (based on the average orbital velocity of the moon with a miss of only 41 miles) the Soviet scientists had definitely planned to impact the lunar surface. A later Russian announcement admitted the rocket vehicle attained a greater velocity than had been desired.

The fact is that an artificial asteroid can be put into orbit around the sun by simply launching it in any direction and at any velocity greater than the escape velocity of the earth-moon system. Giving *Lunik* a short lifetime (62 hours) radio power system when solar power could have been supplied *(Sputnik III* was so equipped) does not seem reasonable if an orbit of the sun had been planned as the major objective.

Space flight capabilities—The RAND Corp., in a scientific analysis for the Select Committee on Astronautics and Space Exploration, outlined what could be done with U.S. ballistic missiles in five years or less. Using adaptations of basic IRBM and ICBM hardware, the report said, would permit the following experiments:

1) Orbit satellite payloads of 100-10,000 pounds at 300 miles altitude.
2) Orbit satellite payloads of 25-2500 pounds at 22,000 miles.
3) Impact 50-3000 pounds on the moon.
4) Land, intact, 10-1000 pounds of instruments on the moon.
5) Land, intact, more than 1000 pounds of instruments on Venus or Mars.
6) Place a 1000-lb. instrument probe in the atmosphere of Jupiter.
7) Launch and return men from orbit around the earth.

Avoid false test results with GLENNITE internally ungrounded accelerometers



Now you can avoid one of the major causes of false test results — spurious "ground loop" voltages — by using *internally ungrounded* GLENNITE accelerometers.

These units contain sensitive seismic elements *internally* insulated from the mounting stud by rugged ceramic insulation. You can employ a *single point ground* at the data handling or recording equipment by using a combination of these accelerometers with ungrounded GLENNITE amplifiers and filters.

GLENNITE accelerometers are available in uni- and triaxial models — wide acceleration and temperature ranges.

A complete line of associated ungrounded electronic equipment includes filters, amplifiers, connectors and other related units.

For complete data on Gulton instrumentation systems — grounded or ungrounded — contact your local Gulton representative or write us direct.

Call in Gulton

From transducer to readout, Gulton is capable of meeting all your instrumentation needs. If you have a measurement problem, why not call in a Gulton Instrumentation Engineer. His broad experience in shock and vibration measurement can prove invaluable to you.

GULTON INSTRUMENTATION DIVISION

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Metuchen, New Jersey

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Thousands of Janitrol couplings for high-temperature high-pressure ductwork are proving their reliability on advanced aircraft and missiles: DC-8, 720, 880, 707, KC 135, CF 105 (Mark I and II), F4H, F8U3, P6M, S-55, HR-251, H19D4 H34A, H37A, Regulus II and the Green Quail.

Couplings are furnished in titanium as well as stainless steel; sizes range from 1″ to 36″ diameter. Janitrol coupling reliability is firmly based on a unique combination of research, design, testing and manufacturing facilities capable to handle complete systems including heat exchangers, coolers, and controls.

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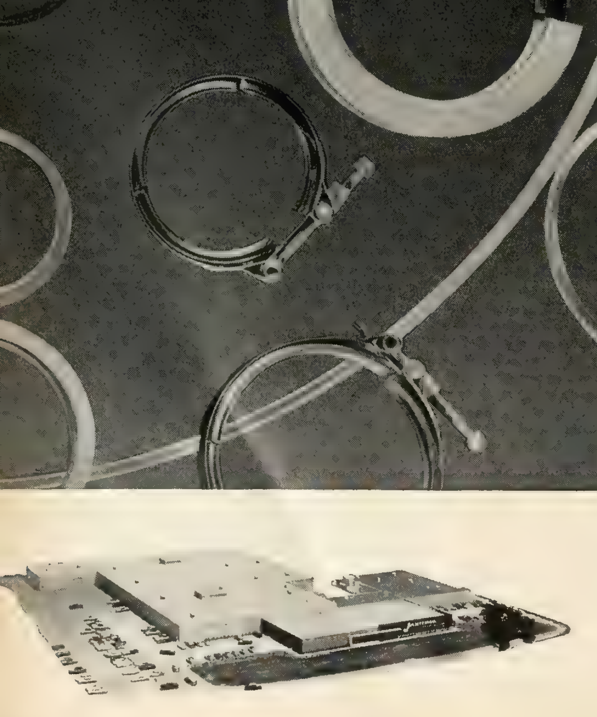


astrionics

by Raymond M. Nolan

Latest entry in the lightweight inertial guidance field is Nortronics' LINS (Lightweight Inertial Navigation System). Starting with a design objective of 35 lbs. for the platform, Nortronics engineers came up with a 30 lb. package. The platform uses the Minneapolis-Honeywell MIG (miniature integrating gyro) gyros and Nortronics-designed digital accelerometers. All preamplifiers and some of the accelerometer electronics are enclosed on the platform. The unit operates at 130°F ambient with integral heaters taking the MIG up to its operating temperature of 180°F. The remainder of the system is packaged in two boxes—one for digital circuitry and one for analog circuitry.

Power for the system is straight 400-cycle because the design was for a Century series lightweight fighter. However, company engineers feel that they can accept the battery input which would be required for missile applications with more ease than the 400-cycle.

A DOD official recently threw a little cold water on the Sperry SINS (Shipboard Inertial Navigation System) now being checked out on the USS Compass Island and planned for use on *Polaris* submarines. The complaint isn't with the equipment itself, which reportedly easily operates to specifications, but with the requirements that some people are talking about in DOD. According to reports, there is some feeling now that SINS should operate with no appreciable drift for about 30 days. This is a considerably greater time than the equipment is designed for.

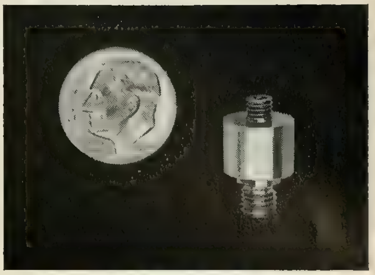
However, some people in industry say that this isn't a worry. Their solution is a high-speed stellar corrector which would adjust the inertial system in the first few minutes after *Polaris* leaves the water. This would eliminate, they say, the requirement for long-range, ultra-precise navigation equipment with an almost impossible to attain remembering capability. Whether or not these objections and solutions have filtered back to the Special Projects section of BuOrd or to Lockheed is not known.

Competition for the successor to the Aerophysics *Dart* continues hot with reports that a demonstration of the French *SS-11* was recently held by the Marines at Quantico and that licensing rights for the German *Kobra* have been picked up by a U.S. manufacturer. This makes three contenders for succession rights, all foreign. In addition, the English Vickers type 891 has been licensed for manufacture in this country and is rumored to be under evaluation now. The Vickers missile has been officially named the *Vigilante* by Vickers-Armstrong. This goes along with V-A practice to tab all their products with names beginning with V.

The *SS-11* demonstration was labeled by some observers as a limited success and by others a dismal failure. At any rate, the French had several failures, including one for wire breakage and another which would not leave the helicopter-borne launcher. However, the few missiles that did operate without malfunction were on target.

Whatever the outcome, the U.S. will be getting a bargain in the wire-guided, anti-tank missile it chooses since all three are essentially fully developed. Some minor redesign might be necessary to comply with military specs, but manufacturers and importers of the missiles are keeping their fingers crossed since they are in general agreement that too much tinkering around was what really killed the *Dart*.

525° F plus
internal
ungrounding



You get both in this Glennite® piezoelectric accelerometer

Now, for the first time, you can have extremely high temperature range *plus* the advantage of *internal* ungrounding.

Heretofore supplied grounded, the AXT321 is now available for applications where "ground loops" must be avoided.

The new ungrounded AXT321TMU, developed for use in extreme environments, can be operated continuously without temperature compensation.

It has excellent accuracy and reliability, high resonant frequency, small size, light weight.

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Acceleration Range:	0.1 to 300 g
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Resonant Frequency:	10,000 cps
Capacitance:	500 μμf
Temperature Ranges:	—100° F. + 525°F
Sensitivity:	5 mv/g min.
Weight (Approx.):	5.5 grams

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In Canada: Titania Electric Corp. of Canada, Ltd.
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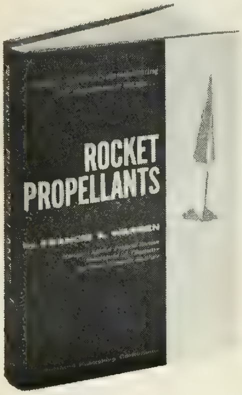
Includes chemical, manufacturing and performance details...

ROCKET PROPELLANTS

by FRANCIS A. WARREN

Manager, Special Projects Section,
Department of Chemistry,
Southwest Research Institute



1958,
228 pages,
$6.50

The purpose of this book is to provide technical men with basic information on the materials being used to propel the rockets and missiles of today, and to recount in an objective manner the fascinating story of rocket fuel development.

It contains the composition, manufacturing methods, and performance details of both solid- and liquid-propellants used in rockets, from small signal units to the largest missiles currently being launched. The book also includes chapters on propellant burning, ignition and igniters, and the various rockets that use each kind of fuel. There is comprehensive information on safety in the propellant manufacturing plant, and quality control of the product.

A final section looks to the future of the present fuels, and reviews the theories that may lead to new ones, such as ion and photon propulsion, and anti-gravity.

CONTENTS: Propellant Systems; Propellant Ingredients; Solid-Propellant Manufacture and Processing; General Performance Characteristics; The Burning of Propellants; Ignition and Igniters; Solid-Propellant Rockets; Liquid-Propellant Rockets; Safety; Evaluation and Quality Control; The Future of Propellants.

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. . . space station

(Continued from page 20)

ment of radiation equilibrium conditions. Kramer and Byers emphasize that these conditions are being studied intensively under *Dyna-Soar* and problems encountered in designing the reentry vehicle should be similar to those of the boost-glide vehicle.

- **"Astrotug" design**—The workhorse in the satellite construction would consist of two double-walled pressure vessels 10 feet in outside diameter, 9 feet inside, 20 feet long, and weighing over 20,000 pounds fully loaded. The vessels would include compartments for the crew, and mounting surfaces for external equipment such as radar, antennas, and search lights.

Propellants for the rocket would be the hypergolic combination of fluorine and hydrazine to ensure reliable ignition in a vacuum.

- **Booster rocket system**—The three-stage boster rocket would be 180 feet long, with a base diameter of 18 feet and a first-stage fin span of 52 feet. The fins would stabilize the first stage during ascent, and act as lifting surfaces during recovery. Four turbojet engines mounted on the aft section of the first stage would supply supplemental power during launch and sustainer power for the return to base of the expended stage.

Launch gross weight of the booster would be approximately 300 tons with a payload weight of 20,000 pounds.

The engine for the first-stage system would be a 1.16 million-pound thrust unit operating at a chamber pressure of 600 psi. Kramer and Byers selected a "plugged-nozzle" design being developed by General Electric. Burning time for the engine would be 90 seconds.

The second-stage propulsion system would have a 321,000-pound thrust engine burning a hydrogen-fluorine combination for 200 seconds. Third-stage engine would be similar to second-stage with a thrust of 76,000 pounds for 175 seconds.

- **System schedule**—Kramer and Byers say success in the space-station development will depend on information to be supplied by four major programs. These are the *X-15* probes extending into 1964, Man-in-Space orbiters, 1960-65, *Dyna-Soar*, 1961-66, and a minimum space station (one or two men), 1962-67.

Answers supplied by these programs should, according to the Lockheed scientists, be sufficient for initiating an orbit rendezvous development. The multi-manned scientific space station would be possible by early 1964, with an operational station by 1968.

MISSILE ENGINEERING

The "collapsing of time" concept has taken on added significance as a result of the current international situation. In Tucson, Arizona, Hughes has established the Tucson Engineering Laboratory for the purpose of shortening the elapsed time between missile development and its effective tactical use. This activity, established over 2 years ago, has proven that the quasi-simultaneous development and production of missiles can become a feasible reality.

The Tucson Engineering Laboratory is now expanding its scope of operations. Mechanical Engineers, Electrical Engineers, or Physicists who like to work on urgent problems and who have the ability and enthusiasm to constantly improve the product and its reliability, will find this an ideal environment. Specific areas of interest include: missile system analysis, infrared and radar guidance systems, electromechanical and hydraulic control systems, missile and test equipment and electronic circuit design.

An added advantage: Tucson's dr healthful climate. Investigate b sending resume to Mr. W. A. Barne at:

the West's leader in advanced electronics

HUGHES

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Tucson, Arizona

contract awards

AIR FORCE

y Ballistic Missile Division:

1,000,000—**Crosley Division, Avco Manufacturing Corp.,** Cincinnati, for new type of Command Receiver.

y Ogden Air Materiel Area, Hill AFB, Jtah:

533,036—**Boeing Airplane Co., Pilotless Aircraft Division, Seattle,** for technical data for *Bomarc* missile components (six contracts).

y Strategic Air Command:

400,000—**Telecomputing Corp.,** Los Angeles, for data processing services at Vandenberg AFB, Calif.

ARMY

y U.S. Army Ordnance District, Philaelphia:

847,350—**Western Electric Co., Inc.,** New York City, for *Nike* spare parts (nine contracts).

17,800—**Princeton University,** Princeton, N.J., for research and development on guidance.

y U.S. Army Engineer Research and evelopment Laboratories, Ft. Belvoir, 'a.:

511,189—**General Mills, Inc., Mechanical Division,** Minneapolis, for automatic tracking theodolite equipment for artillery survey system.

y U.S. Army Ordnance Missile Comand, Redstone Arsenal, Ala.:

300,000—**Southern Associated Engineers, Inc.,** Huntsville, Ala., for 75,000 manhours of technical services in missile and rocket programs.

253,568—**Recordak Corp., Subsidiary of Eastman Kodak Co.,** New York, for microfilming of drawings and mountings of images into aperture cards and full operation of microfilming facilities for ABMA.

34,377—**The William Brand and Co., Inc.,** Willimantic, Conn., for cable.

29,659—**Reynolds Metals Co., Inc.,** Richmond, Va., for aluminum tubing, angle, sheet and plate.

46,189—**John B. Moore Corp.,** Nutley, N.Y., for solvent oxylene.

y District Engineer, U.S. Army Engieer District, Fort Worth:

134,092—**Suggs Construction Co.,** Big Spring, Tex., for storage of base of rocket assembly at Big Spring AFB.

high-energy fuel briefs from Callery

Successful start-up for new Muskogee, Oklahoma plant — Callery is successfully operating the first of four major processing units at the new $38,000,000 Navy HiCal plant at Muskogee, Oklahoma. This plant will provide many times the production capacity of any existing high-energy fuel facility.

Lawrence, Kansas plant producing tonnage quantities of HiCal — All of the immediate capacity of the Lawrence plant is now under military contract. However, we do hope to have some HiCal available in the near future for *authorized users.* If you — or your program — qualify, we'd welcome an opportunity to discuss the technical aspects of using these fuels for your project.

Write for new HiCal-3 Handling Bulletin.

R & D on new fuels and propellants? — Callery's R & D experience may prove helpful in attaining your long range objectives. Our current exploration in a number of new phases of development may coincide with one or more of your pet projects. Project teams with up-to-date facilities at their disposal can now be assigned to new programs. We'd like to talk with you about those areas of mutual interest in which Callery is best qualified.

Pyrophoric ramjet fuel: Triethylborane — TEB is spontaneously flammable in air. However, it does not react with water, and this is a distinct handling and operational advantage. TEB — with much wider flammability limits than hydrocarbons — virtually eliminates engine flameouts at high altitudes. Some of the advantages of using TEB as a primary ramjet fuel in place of hydrocarbon-fueled ramjets are: higher altitude operation, increased range, improved fuel economy and reliability, and lower cost vehicles.

Write for Technical Bulletin C-310 and Handling Bulletin C-311.

New 15-minute Triethylborane-Tributylborane fire-fighting film available for loan. Just write 9600 Perry Highway, Pittsburgh 37.

Washington, D. C. office opened by Callery — Fuel and propellant users in the Washington, D. C. area may now avail themselves of technical service at this new Callery office: Room 709, DuPont Circle Building, 1346 Connecticut Avenue, N.W. Phone Richard A. Carpenter, Manager, ADams 4-4200.

Note: Our recently opened office in Dayton, Ohio offers specialized technical assistance on fuels and propellants to interested parties in that area. Contact Anthony C. Hummel at 2600 Far Hills Avenue, phone AXminster 3-2752.

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CHEMICAL COMPANY
9600 PERRY HIGHWAY
PITTSBURGH 37, PENNSYLVANIA

Richard A. Carpenter
Manager, Washington Office
Callery Chemical Company

IMPORTANT ANNOUNCEMENT TO ALL ENGINEERS—EE, ME, AE, CE:

A New Organization Now Forming at General Electric to Integrate and Direct Systems Management of Prime Defense Programs

From within General Electric, and from industry at large, talented scientists and engineers from diverse disciplines are coming together to form the nucleus of the new Defense Systems Department.

The responsibilities of this new group encompass management of theoretical and applied research as well as advanced development on major terrestrial and space-age systems.

Engineers and scientists interested in exploring the broad new possibilities in the Defense Systems Department are invited to investigate current openings.

Direct your inquiry
in confidence to Mr. E. A. Smith
Section G

DSD

DEFENSE SYSTEMS DEPARTMENT
GENERAL ELECTRIC
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SYRACUSE, NEW YORK

when and where

JANUARY

Southwest Electronic Exhibit, Arizona State Fairgrounds, Phoenix, Jan. 21-23.

Fifth Annual Radar Symposium (classified), Rackham Bldg., University of Michigan, Ann Arbor, Jan. 27-29.

Society of Plastics Engineers, 15th Annual Technical Conference, Hotel Commodore, New York, Jan. 27-30.

Armour Research Foundation, Fifth Annual Midwest Welding Conference, Illinois Institute of Technology, Chicago, Jan. 28-29.

Columbia University and Sylvania-Corning Nuclear Corporation, First International Symposium on Nuclear Fuel Elements, Columbia University, New York, Jan. 28-29.

FEBRUARY

14th Annual Technical and Management Conference, Reinforced Plastics Div., Society of the Plastics Industry, Inc., Edgewater Beach Hotel, Chicago, Feb. 3-5.

IRE, AIEE 1959 Solid State Circuits Conference, University of Pennsylvania, Philadelphia, Feb. 12-13.

1959 Engineering Exposition, Balboa Park, San Diego. For information, contact exposition office at 422 Land Title Bldg., San Diego, Feb. 26-March 1.

MARCH

IRE, AIEE and Association for Computing Machinery, 1959 Western Joint Computer Conference, Fairmont Hotel, San Francisco, March 3-5.

Second Western Space Age Conference and Exhibit, Great Western Exhibit Center, Los Angeles, March 5-7.

Institute of the Aeronautical Sciences, Flight Propulsion Meeting (classified), Hotel Carter, Cleveland, March 5-6.

Western Space Age Conference and Exhibit. For information: Domestic Trade Dept., Los Angeles Chamber of Commerce, 404 South Bixel St., Los Angeles, March 5-7.

Gas Turbine Division of the American Society of Mechanical Engineers, Turbine in Action, Cincinnati, March 8-11.

Advertising correspondence should be addressed to Advertising Sales Manager, Missiles and Rockets, 17 East 48th Street, New York 17, N.Y.

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Structures for tomorrow's aircraft and missiles

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Avco's new Nashville Division (formerly a part of the Crosley Division) boasts an enviable 17-year record of building components for some of the country's most important aircraft, including the B-52, B-47 and B-36.

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C-130 Hercules transport—complete empennage.

F-102 Delta Dagger—wing trailing edge.

F9F Cougar—horizontal stabilizer, flaperons and flaperettes.

Looking ahead, the Nashville Division has prepared itself to contribute to the Mach 3 aircraft and Mach 10 missiles that soon will go into production as part of the nation's defense effort.

The Nashville Division's skilled personnel have demonstrated their know-how in producing Avcomb, contoured stainless steel honeycomb panels. They long ago proved themselves in the production of aluminum honeycomb structures, and other advanced manufacturing techniques, such as metal bonding and chemical milling.

Avco/Nashville

Avco/Nashville: proven . . . ready for tomorrow

For further information, write:
General Marketing Manager—Structures,
Nashville Division, Avco Manufacturing
Corporation, Nashville, Tennessee.

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THIOKOL

REDSTONE

DIVISION AT HUNTSVILLE, ALABAMA

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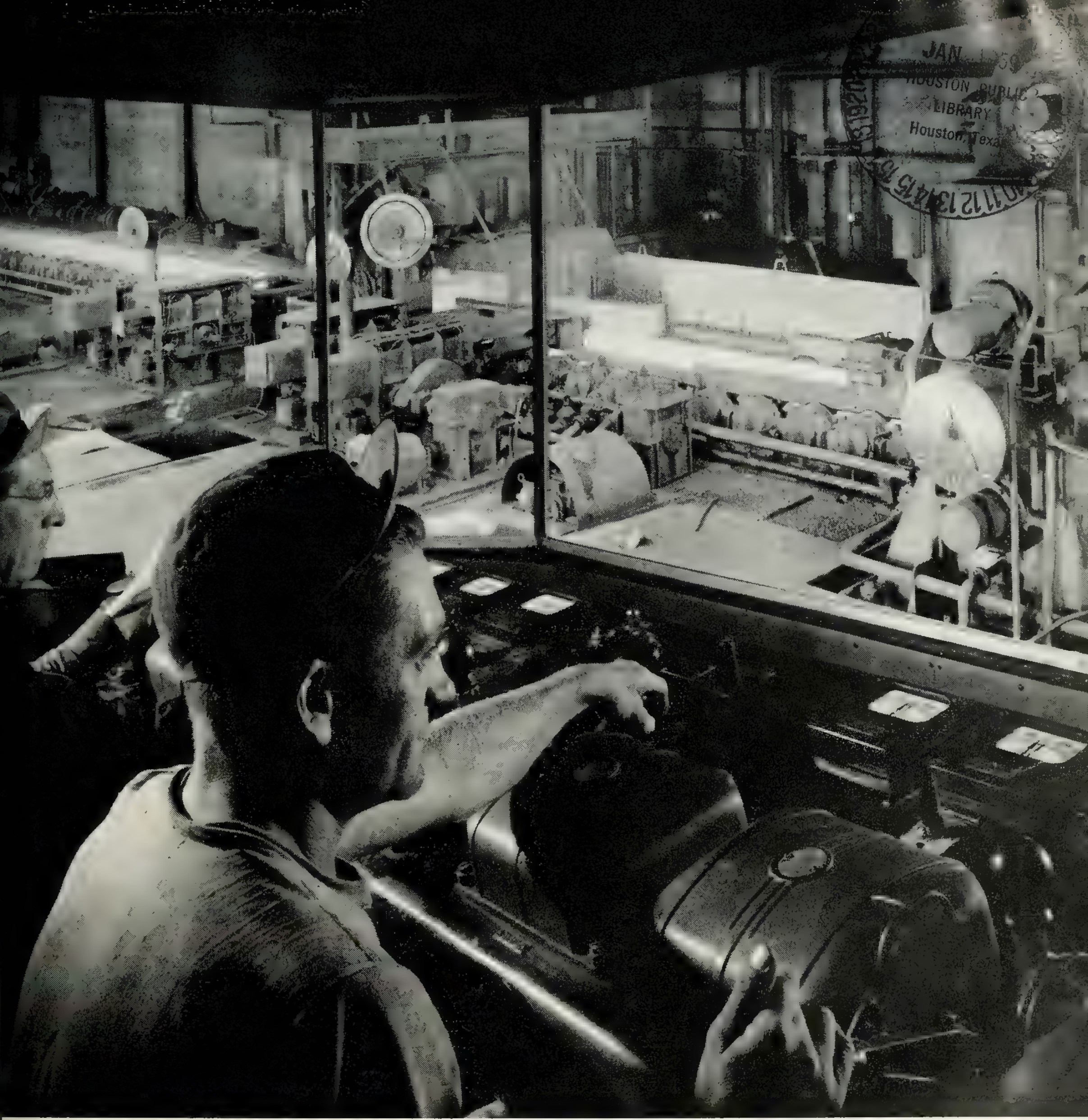
ALLOY STEELS FOR MISSILES

JANUARY 26, 1959



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missiles and rockets

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3. MANUFACTURING EXPERIENCE: KIN TEL has manufactured over 10,000 "standard cell accuracy" DC instruments on a true production line basis. Only by this method, by years of repeated manufacturing experience, by an over-all awareness of the accuracies and tolerances involved, is it possible to guarantee consistent accuracy and reliability...to assure real value for every dollar you invest.

4. NATIONWIDE APPLICATION ENGINEERING FACILITIES: KIN TEL has engineering representatives in every major city. An experienced staff of over 200 field engineers is always immediately available to help solve your application problems, provide technical data, or prepare a detailed proposal. Factory level service is available in all areas.

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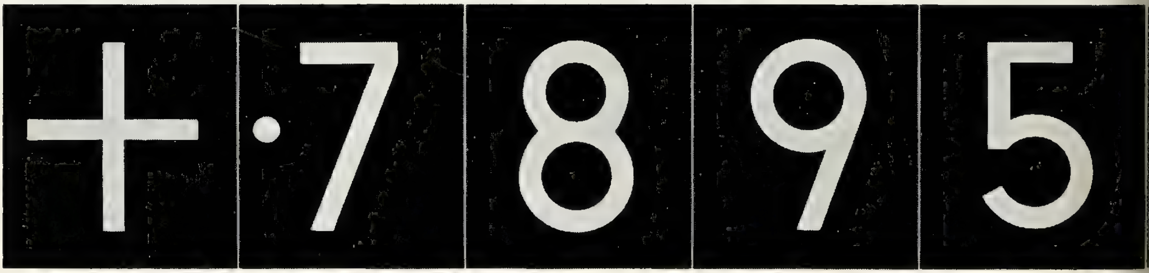
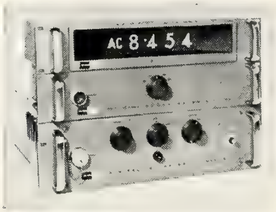
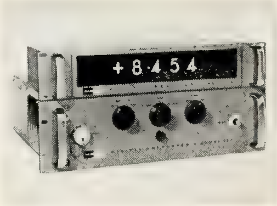




Model 402B AC/DC 4-digit



Model 401B DC 4-digit

Model 501 DC 5-digit

6. WIDE RANGE OF MODELS–ACCESSORIES–SPECIAL SYSTEMS: Versatile "digital building blocks" permit measurement of AC, ohms, ratios of AC and DC, automatic scanning of multiple inputs...4- or 5-digit models. Preamplifiers increase digital voltmeter sensitivity to 1 microvolt DC, 10 microvolts AC. Buffers permit driving typewriters, tape punches and printers. KIN TEL's Special Products Department can design and manufacture digital instruments to meet special requirements...complete digital systems for data logging, missile checkout and automatic production line testing.

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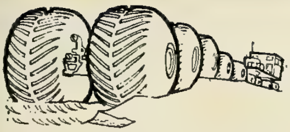
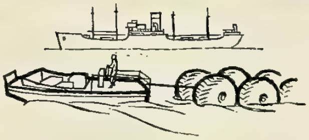
Does your weapon system need fuel "on the double"?

Here – from Goodyear – are ingenious new rubberized containers that offer double dividends: lightweight liquid storage plus unmatched all-weather mobility.



NEED FUEL THAT ROLLS WITH YOU?

These big Rolli-Tankers hold 500 gallons each, can be towed in long "fuel trains" over roughest terrain. Tire-like containers roll so easily a man can pull one.

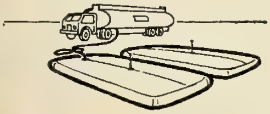


— OR FLOATS WITH YOU?

Filled with fuel, Rolli-Tankers have natural buoyancy – ride through water, roll right up the beach! Eliminates long-line hoses and pumping.

— OR COMES BY AIR?

Delivered by air, Rolli-Tankers can be attached to waiting trucks *—and rolling—*in matter of minutes. Fully loaded tankers survive free falls of 15 feet.

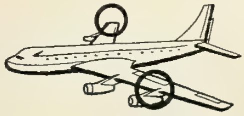


HOW ABOUT A PORTABLE FUEL FARM?

Called "Pillow Tanks," these tough, rubberized fabric containers can be set up, filled and pumping in 45 minutes. Great where temporary or emergency storage of bulk liquids is needed.

LOOK! FLOATING FUEL STATION

"Pillow Tanks" *in the water* serve as "fuel islands"—eliminate stringing of long-line hoses or pumping from remote point. Tanks available in sizes up to 50,000 gallons.



WANT TO SAVE FUEL SPACE?

Goodyear has pioneered the development of spacesaving fuel cells and tanks for aircraft, boats, vehicles, missiles. This experience can best answer *your* fuel storage problem.

FOR COMPLETE INFORMATION on these and other new developments in fuel storage and transport, write Goodyear, Aviation Products Division, Akron 16, Ohio, or Los Angeles 54, California.

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GOODYEAR

Rolli-Tanker—T. M. The Goodyear Tire & Rubber Company, Akron, Ohio

what can you do with this versatile
FLUID HANDLING HARDWARE?

H₂O₂ NOZZLE and ADAPTER
Model QD-7

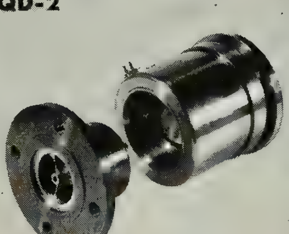
Fast, safe, easy servicing of aircraft and missiles. Adaptable for other fluids.

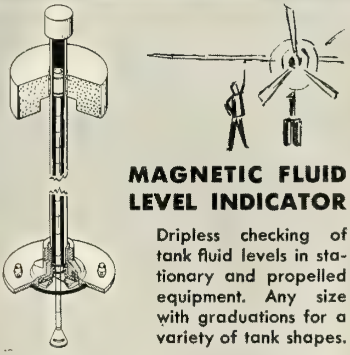
- Self-sealing
- Lightweight
- Working parts isolated from fluid
- Nozzle must be locked to adapter to actuate internal valves
- Sizes: 1½" to 8" I.D.
- 50 to 1,500 gpm.

QUICK DISCONNECT Model QD-2

For mercury-cooled nuclear power plants or conventional systems. Can be modified for remote operations and a wide range of fluids, gases or liquid metals.

- "Push-to-lock", "pull-to-open"
- Both halves self-sealing
- Can't disconnect during flow operations
- Proof pressure — 300 psi.
- Sizes: ½" to 6" I.D.





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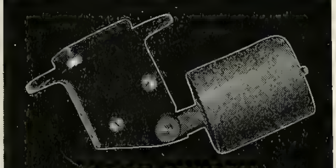
Dripless checking of tank fluid levels in stationary and propelled equipment. Any size with graduations for a variety of tank shapes.

- Easy, under-the-tank check
- Lightweight
- Easy to install
- No power requirements
- No complex hidden linkages



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Model FS-2

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- Enclosed switch mechanism
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missiles and rockets

MAGAZINE OF WORLD ASTRONAUTICS

Cover: Acme-Newport Steel Co. Reduces ingot to plate for astronautics work. (p. 24)

JANUARY 26 HEADLINES

$7 Billion for Missiles; $830 Million for Space

President sends $77 billion budget to Congress; *Minuteman, Hound Dog, Polaris* programs to benefit; ARPA and NASA budgets increased 21

ASTRONAUTICS ENGINEERING

1959 Missile Materials Outlook

What are the prospects for metals, ceramics and plastics to meet demands of high temperatures, strength, lightness and corrosion resistance? The answers are provided by m/r Propulsion and Chemistry Editor Alfred J. Zaehringer in this special review 24

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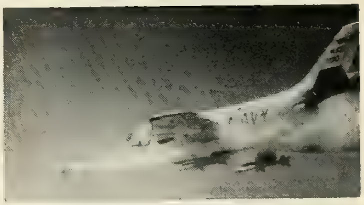
SPARROW III IN ACTION . . .

Rapid fire sequence shows second generation air-to-air missile in action.

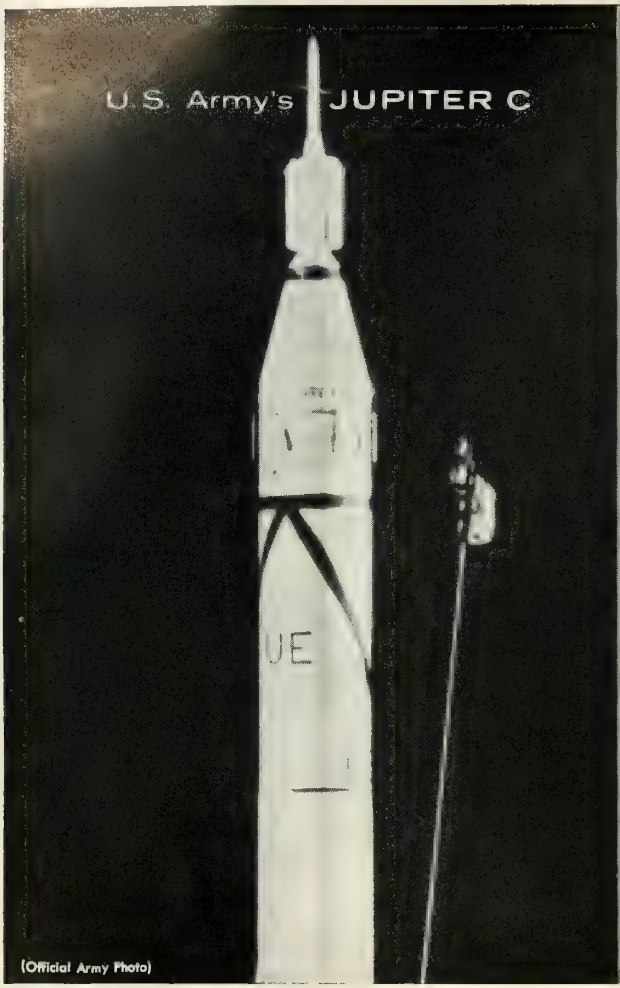


F3H-2 Demon can carry four *Sparrows,* fired either singly or in rapid series.

Warhead delivers 50% more explosive force than other air-to-air guided missiles.

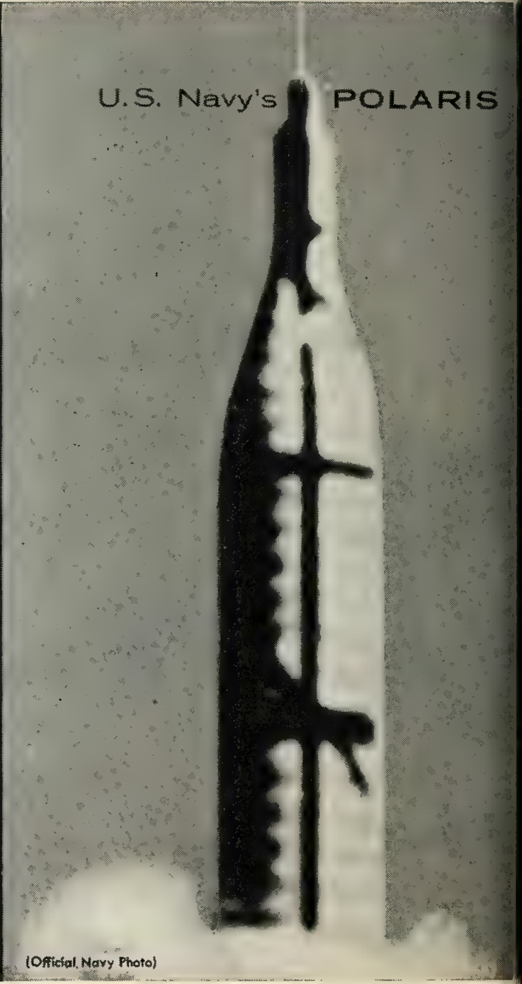
Raytheon missile will fire at target automatically when it comes in range.

Republic is the world's largest



U.S. Army's JUPITER C

(Official Army Photo)

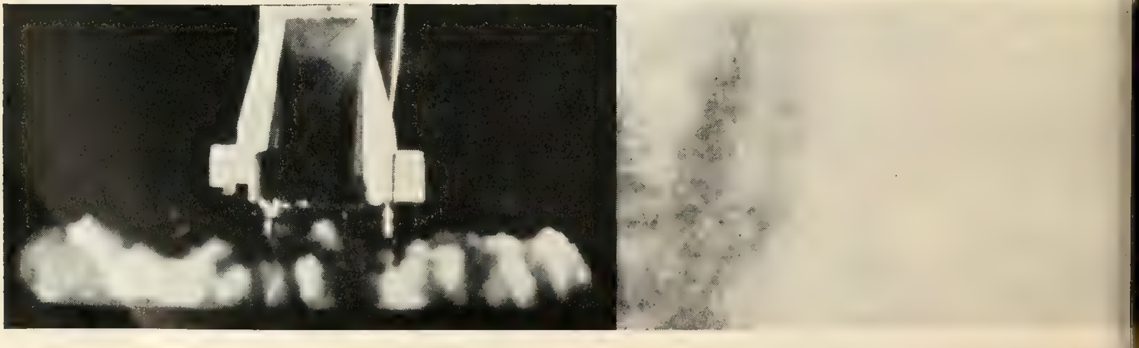


U.S. Navy's POLARIS

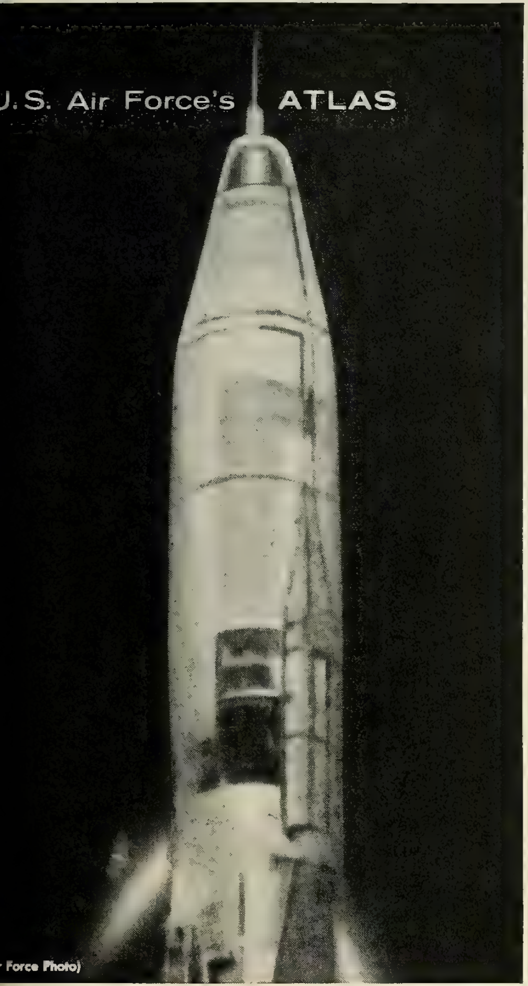
(Official Navy Photo)

STAINLESS STEEL...for heat resistance•TITANIU

ALLOY STEELS...for hig



producer of Missile Metals



Many types of missile metals are required to meet the severe demands of the space age. Metals to resist heat, to reduce weight, to add strength. Production of these flight weight metals is a Republic specialty.

Stainless steel protects missiles and rockets from the searing heat of air friction. Titanium alloys offer the highest strength-to-weight ratio of any construction metal. Republic produces both of these metals in billets, hot rolled and cold finished bars, plates, sheets, and strips.

Republic Alloy Steels are continuing to play a prominent part in the development of operating and structural parts free from excess weight, yet tough and strong to withstand shock, impact, strain, and vibration.

As rapid development in the missile field increases demand for these high-strength, select formula steels, Republic is keeping pace through research and new production facilities.

Republic metallurgists and engineers will be glad to work with your personnel in developing the most advantageous use of Republic Stainless Steels, Titanium and Alloy Steels. There's no obligation. Check and mail the coupon if you would like a Republic specialist to call at your plant.

REPUBLIC'S NEW HIGH STRENGTH POWDER, TYPE HS 6460, opens the way for sinterings for highly stressed parts in aircraft and missiles. Type HS 6460 can be used with existing operating equipment. It provides a minimum tensile strength of 60,000 psi at 6.4 density as sintered, and 100,000 psi heat treated. Type HS 6460 maintains its dimensional characteristics after sintering—less than .004 inches per inch shrinkage from die size at 6.4 density. Available in production quantities up to and including 12 tons, or multiples thereof. Mail coupon for technical data sheet on Type HS 6460 Powder.

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strength

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Address________________________

City____________ Zone_____ State______

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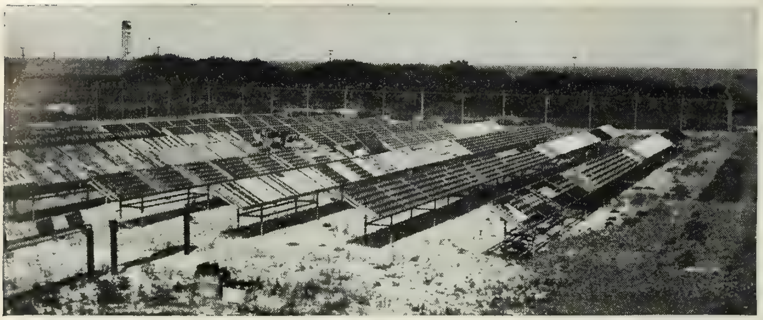
THE FACTS ABOUT MAGNESIUM AND CORROSION

Once this basic law of nature is recognized, proper design and protective measures permit excellent service life.



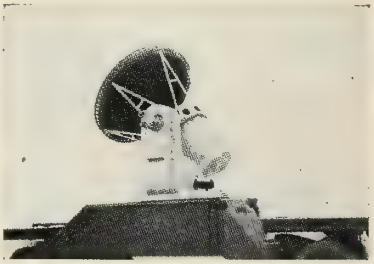
EXPOSURE TESTS on many assembly protection methods and new finishing developments are constantly in progress on these seaside test racks (International Nickel Test Station, Kure Beach).

MAGNESIUM, the world's lightest structural metal, has a successful history of application in aircraft, missiles, military ground equipment, portable tools, and materials handling equipment.

Yet some designers and production men hesitate to use magnesium because they have heard that it "corrodes." What are the facts about this important matter?

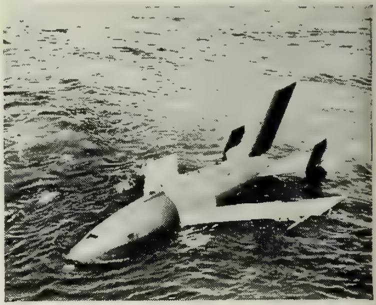
It's quite true that magnesium corrodes under certain environmental conditions—as does every other basic structural metal. Each has its own distinct corrosion "personality" in the presence of corrosive elements. For example, magnesium has excellent resistance to corrosion in strongly alkaline surroundings and readily becomes subject to attack under acidic conditions. Conversely, aluminum is resistant to many acids but suffers attack in strongly alkaline environments.

Approximately 95% of all corrosion problems with magnesium stem from galvanic corrosion. This type of corrosion is caused by differences in the electrical potential of dissimilar metals coupled together and immersed in an electrolyte. By understanding the source of corrosion currents, metals and their environments can be controlled so as to minimize or eliminate these sources. Techniques of joining magnesium to other metals have been developed which effectively overcome the conditions causing galvanic corrosion.



NIKE GROUND GUIDANCE—Large magnesium assemblies are easily and effectively protected by standard finishing methods.

The corrosion behavior of metals is as much an inherent characteristic of materials as tensile strength, elongation and other physical properties. The laws of corrosion are well understood. Thus they can—and should be—taken into full consideration in any design analysis of a product or part. With this concept in mind, almost any corrosion problem can be "designed out" from the beginning when working with magnesium.



RYAN FIREBEE, with 75% of it's exterior surface magnesium, has withstood repeated dunkings in the ocean with no adverse effects. The reason—Ryan applied the proper protective measures.

Whenever the corrosion characteristics of magnesium are acknowledged, and preventative measures are incorporated into designs, magnesium gives outstanding performance in service. Proof of this statement is evident by the growing use of magnesium alloys for such applications as: aircraft skins, wheels and engines; missile frames, fins and skins; radar antennas; military vehicle platforms and wheels; chain saws, hand trucks and dock boards.

TO AID YOU IN APPLYING the correct design and proper protective measures for magnesium, write for your free copy of "MAGNESIUM FINISHING". Either contact your nearest Dow Sales Office or write to THE DOW CHEMICAL COMPANY, Midland, Michigan, Department MA 1483 CL 1-26.

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Space Technology Laboratories, Inc. P.O. BOX 95001, LOS ANGELES 45, CALIFORNI

The 250′ radio telescope pictured here is operated by a team of British scientists under the direction of Professor A. C. B. Lovell, University of Manchester, whose cooperation contributed materially to making this achievement possible.

Neither Life nor Defense Ends at 40

There are any number of questionable things in the President's proposed federal budget for Fiscal Year 1960 (like basing its balance on some highly dubious proposed legislation) but m/r's chief quarrel is with the way it plays fast and loose in a numbers racket with the security of the country.

The President and the administration seem to be preoccupied with the number "forty." Is it magic? For three years—1958, 1959 and now 1960—the budget of the Department of Defense, which includes the services, the Advanced Research Projects Agency and the Office of the Secretary of Defense itself, has been arbitrarily pegged at $40 billion, plus or minus about the cost of one missile launching.

Comes *Sputnik,* comes *Lunik,* comes hell or high water, the security of the United States of America seems to be rated at $40 billion. There isn't even an increase for the rising cost of living, let alone the cost of a million-pound-thrust engine or a multi-ton satellite which would help us gain parity with the Russians in the space race.

Instead of an adult acceptance of the country's situation and an honest approach to solution, we are given figures, previously arrived at, which don't mean exactly what they say. (And, incidentally, don't say it the same way twice throughout the 1027 pages of the budget book—What a spot for some R&D on standardization.)

We are informed, for instance, that the budget includes some $5½ billion for military research and development—a healthy increase over the previous two years—and then shyly told that this sum includes test and evaluation support. This is another way of saying that the money for the very expensive test hardware and test activities—such as range operation—now comes from R&D funds instead of from production and procurement as it had before.

We are told that the budget for Fiscal 1960 includes about $7 billion for missiles—and then comes the admission that this really means missile systems and that includes about everything except the blockhouse sink. It takes in, for example, the cost of the *Polaris* submarine being constructed to fire the *Polaris* missile. It takes in the cost of constructing *Titan* bases—right down to the cement hardstands—at Cheyenne. This may be all right and proper but why not say so plainly? How much are we going to spend for actual missiles which would give us some measure of our defense situation?

Nestling in the budgets for the National Aeronautics and Space Administration and the Advanced Research Projects Agency is something on the order of $700 million to be spent during Fiscal 1960 on space projects, both peaceful and military. This figure must encompass research, development and testing of every space project accomplished during 12 months. It must cover such items as the *Discoverer* program, under ARPA, which envisions a dozen or so satellites in orbit, possibly ending with a reconnaissance camera.

It must cover NASA's Project *Mercury,* which hopes to place mice, monkeys and men in a space capsule to orbit the earth and be recovered. It must cover a million-pound-thrust engine in one piece (NASA) and a million-and-a-half-pound-thrust engine clustered (ARPA). Elsewhere in this issue are more detailed listings of the roles and missions of these two agencies on whose talents (and budgets) rest the future security of the country, from a space point of view.

And it's business as usual for the nuclear-powered airplane and its capability as a missile launching platform. About the same amount will be spent on this project in 1960 as in 1959, the President said. This, incidentally, was darned little.

Rep. George Mahon, chairman of the House Defense Appropriations Subcommittee, should find a great deal of support for his attitude after reading the budget. He said:

"There is every likelihood that the 1960 defense budget will be found wanting. The American people are willing to pay for adequate defense. And I propose to put the defense program ahead of budgetary considerations."

We believe the people of this country would prefer to face up to, deal with and pay for an honest and forthright defense program, rather than be fooled by figures which add up to a magic number.

Clarke Newlon

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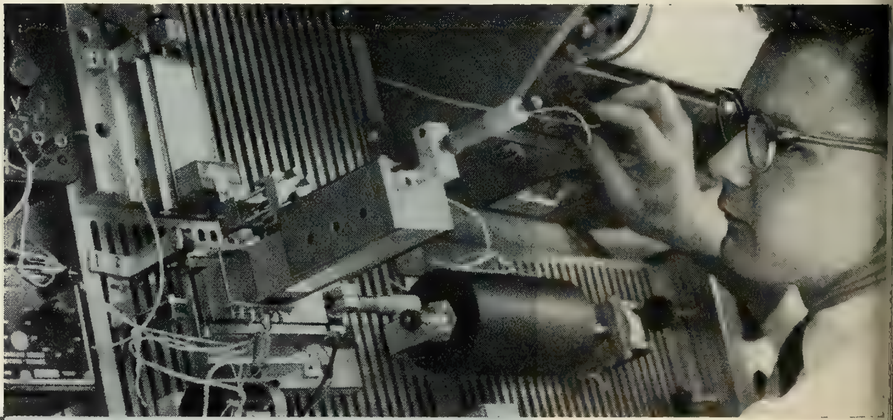

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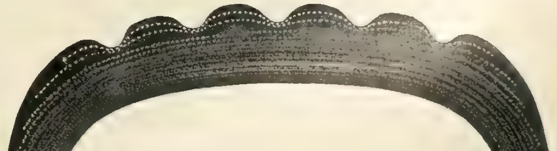

Cross-section of Fabric Tread Tire showing nylon laminates

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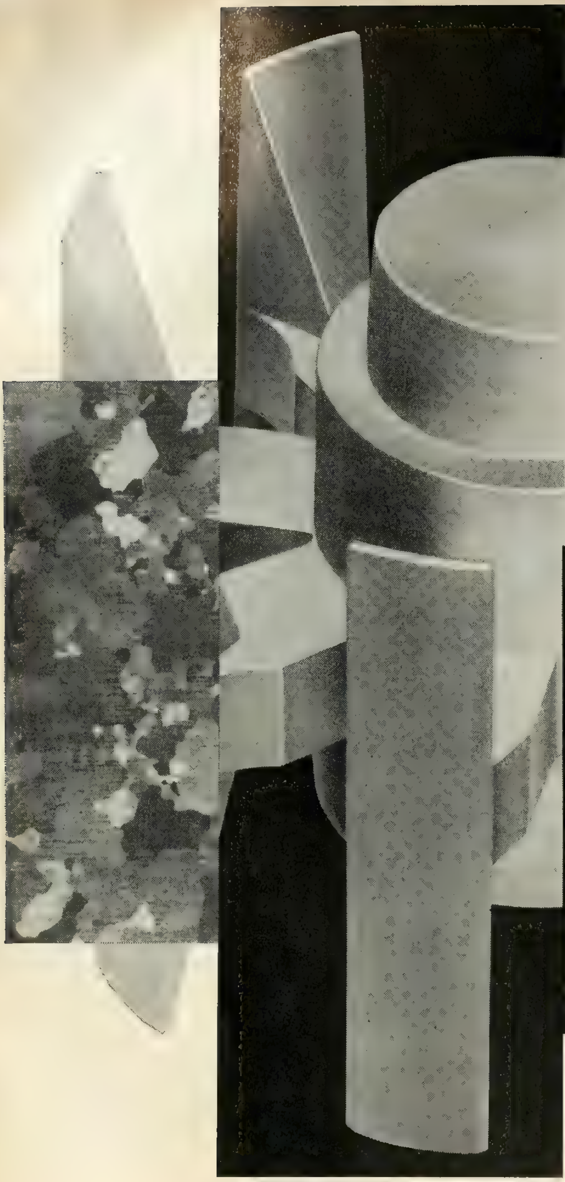

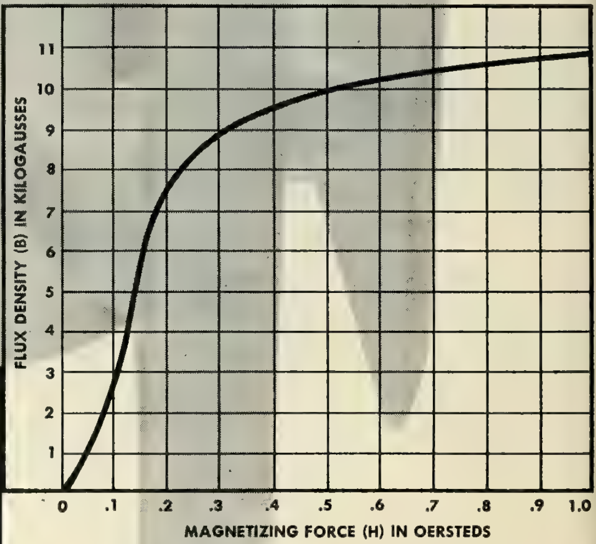
FLUX DENSITY (B) IN KILOGAUSSES
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washington countdown

Russian IRBM's . . .

are zeroed-in on every major installation in Western Europe, except two airbases in Spain, Rep. Daniel Flood (D-Pa.) told m/r. Flood said the IRBM's are 90% effective, compared with 50% for *Thor* which will be operational about March 1. Russia has 50 ICBM's but they are only 50% effective. And by the time the West has a 50% effective operational ICBM, the Reds will have 10 times as many with an efficiency of 90%, Flood said.

Look for Dr. Herbert York . . .

to take more and more direct authority over the services in R&D matters, up to having one-man authority over service R&D projects. If and when Roy Johnson should leave as head of ARPA, his successor will probably report to York instead of the Secretary of Defense.

A combined R&D budget . . .

for all services would be an advantage, a defense spokesman told reporters at the OSD budget briefing. That could easily be a forerunner of a complete combined defense budget.

3,000 mile *Polaris* . . .

poses no real problems, according to Rear Adm. William F. Raborn. He said the Navy is planning to put the longer-range IRBM on carriers and cruisers. It would be lengthened to carry more fuel. Cost is estimated at about $25 million.

Favorable Soviet lunar . . .

probe dates this month are Jan. 26-27. NASA will not launch Pioneer IV, however, until late February, using modified *Jupiter*.

To avoid any incident . . .

in connection with the launching of the first satellite from Vandenberg AFB, plans are to evacuate little railroad community of Surf (about 35 people) and lighthouse at Point Arguello. Only one man—reported to be the railroad telegrapher—will remain in Surf, about five miles south of the launching pads. *Discoverer* launching was scheduled as m/r went to press.

Space committees membership . . .

is shaping up two Democrats for every Republican. Nominations for the House standing committee on space and sciences list 16 Democrats and eight Republicans. The Democratic nominees are: Brooks, La., chairman; McCormack, Mass.; Miller, Calif.; Teague, Texas; Anfuso, N.Y.; Sisk, Calif.; Mitchell, Ga.; Quigley, Pa.; Hall, N.C.; Wolf, Iowa; Karth, Minn.; Hechler, W.Va.; Daddario, Conn.; Moeller, Ohio; King, Utah; and Roush, Ind. GOP nominees are: Martin, Mass.; McDonough, Calif.; Fulton, Pa.; Chenoweth, Colo.; Osmers, N.J.; Van Pelt, Wis.; Baumhart, Ohio; and Bass, N.H.

Democratic members of Senate . . .

standing committee on Aeronautical and Space Sciences are: Johnson, Texas, Chairman; Russell, Ga.; Anderson, N.M.; Magnuson, Wash.; Kerr, Okla.; Symington, Mo.; Stennis, Miss.; Young, Ohio; Dodd, Conn.; and Cannon, Nev. The Republicans will have approximately five members.

A Soviet space handbook . . .

published in January, 1958, indicates the Russian space program is on schedule. The handbook listed plans for five space shots of which the first three were to orbit earth satellites, the fourth was to hit the moon, and the fifth was to go into a solar orbit.

12 U.S. satellites will be launched . . .

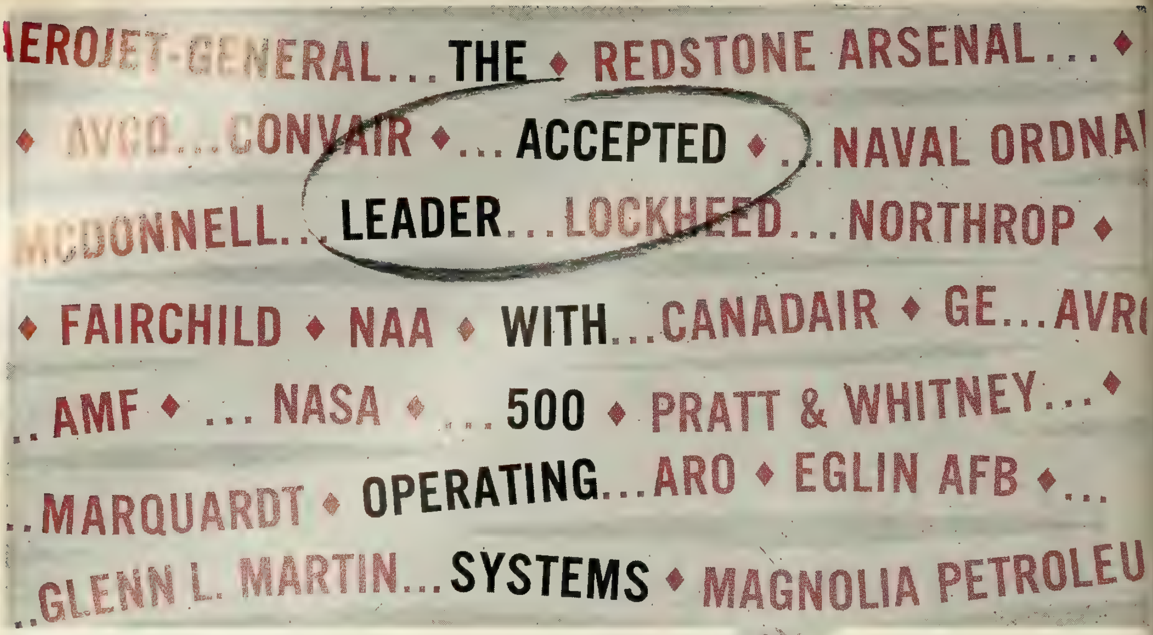
in 1959-60, according to Dr. T. Keith Glennan, NASA Administrator. Glennan said about 40 space probes with upper atmosphere sounding rockets are planned. He favors sharing the costs of satellite launchings with other nations, and said unofficial discussions already have been held between U.S., Canada, Britain, and Russia.

Russian report from 21st Century . . .

passes up trips to the moon as commonplace. Other accomplishments in next 100 years seen by 29 Soviet scientists in a book reviewed by Tass include: concentration on reaching Saturn, Jupiter, Uranus and Pluto; utilization of moon resources; and studying geology, physics and meteorology of other planets.

Many members of the ABMA team . . .

would like to see ABMA become a part of NASA, Dr. Homer J. Stewart, NASA's director of Program Planning and Evaluation, told members of the National Rocket Club. He said only time would tell what ABMA's future status will be, but it would be of great benefit to NASA.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◆ AVCO... CONVAIR ◆... ACCEPTED ◆ ...NAVAL ORDNA
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◆ FAIRCHILD ◆ NAA ◆ WITH... CANADAIR ◆ GE... AVR
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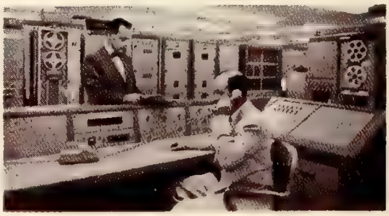

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industry countdown

One hundred contractors . . .

accounted for 74.2% of military funds from July 1, 1957 to June 30, 1958. This is an increase of 5.8% in contracts by the companies over fiscal year 1957. Twenty-four are engaged mainly in missile and aircraft programs and their awards amounted to 56% of the value of all defense contracts of $10,000 or more. Boeing and General Dynamics lead the list and their total percentage was as large as the net increase in the entire list of 100. Boeing contracts increased from $907 million in FY '57 to $2.131 billion in FY '58. Fifty-four percent of the contract awards were sub-contracted with more than one-third going to small business.

Aerojet will expand . . .

solid propellant rocket facilities to meet the increased demands of new projects. An estimated $30 million will be spent for new construction at its solid rocket facility at Sacramento for work on *Polaris, Minuteman,* and *Dyna-Soar*. Expansion includes new machine shops, mixing plants, and static test stands. Employment has increased from 1,450 to 4,200 at the solid facility.

Delivery of *Bullpup* motors . . .

is underway from the Naval Propellant Plant, Indian Head, Md. for fleet evaluation. The solid propellant motor was designed by the Allegany Ballistics Lab., operated by Hercules Powder Co. for the Navy Bureau of Ordnance. The Indian Head plant is producing and loading the motors.

Flight test model . . .

of a variable thrust liquid rocket engine using pyrophoric fuels, already ground tested by its developer—NOTS China Lake—is expected soon. NOTS tested a 10,000 pound thrust version that is similar to one to be installed in the *X-15*.

First molybdenum casting . . .

produced by Bureau of Mines scientists at Albany, Ore., is termed "a major metallurgical breakthrough." The commercial value is still questionable but the process possibly could reduce the steps necessary to make missiles parts, reducing costs. A 30-lb. block of moly was melted in a water-cooled, copper-lined crucible with an electric arc in inert atmosphere. A rotating graphite cylinder mold forced the molten metal into a cylinder 4½ inches in diameter and 8 inches long.

Jupiter may become target missile . . .

for *Nike-Zeus* or other AICBM systems under a Chrysler proposal. ARGMA has given the Detroit firm—already making personnel cutbacks because of phasing out of *Redstone* and *Jupiter* programs—a feasibility study contract. Conversion would consist of reducing complexity of system, including guidance, to make it less expensive.

Stavid Engineering will study . . .

weather conditions for the Army Signal Supply Agency with a $500,000 contract to develop a Sferics system for detecting and locating atmospheric conditions at long range.

Gulf Oil has exercised option . . .

to increase its financial interest in Callery Chemical Co. to 50% by buying a 25% interest. Callery, which opened its $5 million plant in Lawrence, Kan., recently, will continue its present management.

Contract for first ICBM pads . . .

at the Navy's Point Arguello missile facility has gone to Wells-Benz, Inc. of San Diego with a bid of $4.6 million. Contract includes one launch building, two pads and other facilities to be constructed under the direction of the Pacific Missile Range. Ralph M. Parsons Co. designed and prepared specifications under directions of AF Ballistic Missile Division.

Project *Discoverer* pad work . . .

underway at Point Arguello will, informally be completed in 9½ months. Construction involving more than 400 subcontractors calls for two structural steel towers, and two missile launching pads.

Ground support equipment . . .

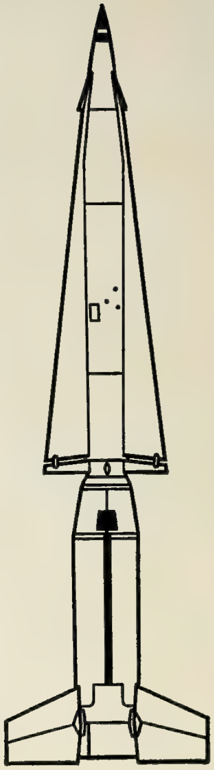
involves more than 50% of the dollar volume in missile systems, according to B. J. Meldrum of Chrysler Corp. Meldrum reports the *Redstone*, system requires a dozen major vehicles packed with intricate equipment to transport, set up, fuel, and fire the missile in the field.

The man:

A U.S. Army missileman working with Nike Hercules missile equipment. The modern Army relies heavily on the special skills and knowledge of men like this who are trained extensively in military schools, and supported technically in the field by Army Ordnance Corps, Western Electric and Douglas field service men.

The mission:

Defense of U.S. cities. Army Nike Hercules units are already on duty at many key points...have the important assignment of guarding against enemy aircraft.



The missile:

Douglas-built Nike Hercules, product of a Douglas-Western Electric-Army Ordnance team, has successfully engaged supersonic drone targets at altitudes well over 60,000 feet. Other drone targets have been destroyed up to 100,000 feet, and at ranges beyond 75 miles.

Status	**Combat ready**
Range	**75 miles plus**
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Warhead.	**Nuclear or conventional**
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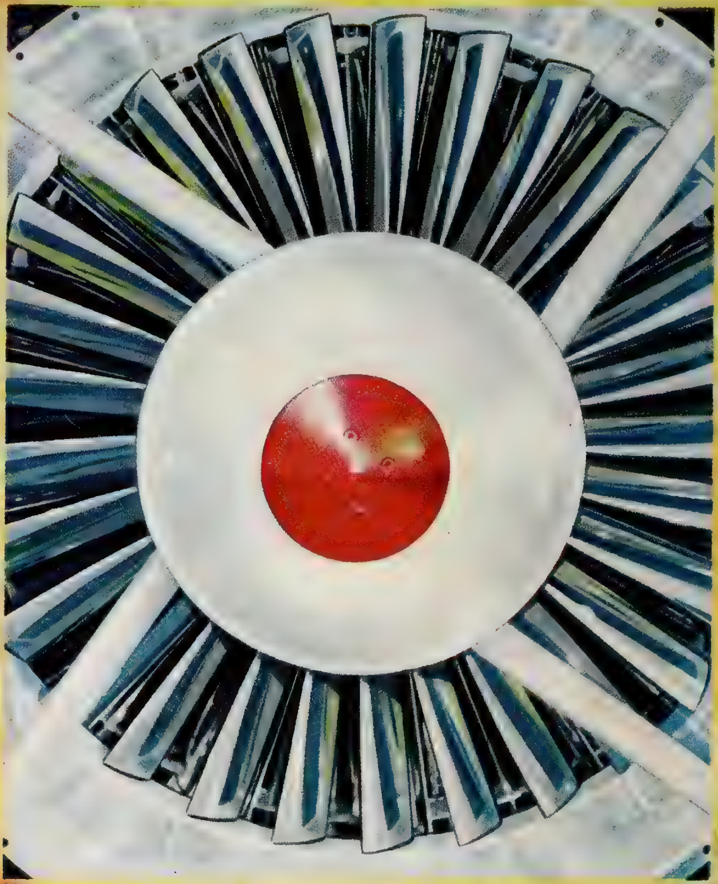

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JANUARY 26, 1959—VOL. 5, NO. 4

missiles and rockets

MAGAZINE OF WORLD ASTRONAUTICS

Budget Holds $7 Billion for Missiles

$830 million for space exploration; *Minuteman, Hound Dog, Polaris, Nike-Zeus* programs to be accelerated in $40 billion defense budget. ARPA wants $455 million; NASA budget is $485 million.

by Clarke Newlon

WASHINGTON—President Eisenhower has presented to Congress a budget for Fiscal Year 1960 which includes $7 billion for missile weapons systems and $830 million for space projects.

The $7 billion figure was set by several budget interpreters, including Defense Department Comptroller, Assistant Secretary W. J. McNeil. The actual Office of Secretary of Defense figure for procurement and production of missiles was $4.162 billion, with the remainder being included in research and development and in ground support appropriations.

However, McNeil said that even the $4.162 billion figure included a great deal of non-missile money even to such items as the submarines which will fire the *Polaris*. (It does not include aircraft, he said, but certainly could include ground support equipment down to cement hardstands.)

Programmed by the National Aeronautics and Space Administration, the Advance Research Projects Agency and the Atomic Energy Commission is the $830 million for space exploration.

The overall U.S. budget totals $77.0 billion. Receipts are anticipated at $77.1 billion, leaving a space-thin $100 million margin of surplus.

Compared to last year, it looks like this:

	1959 (billion)	1960 (billion)
Receipts	**$68.0**	**$77.1**
Expenditures	**$80.9**	**$77.0**
	$12.9 (deficit)	**$ .1 (surplus)**

Of this total, national security gets $45.8 billion, with the Defense Department taking $40.9 billion as compared to $40.8 billion in 1959.

• **Comparison**—The FY 1960 Department of Defense budget (in billions), with FY 1959 in parentheses, is:

New appropriations (or new obligational authority, $40.850 ($41.138); buy money (or direct obligations), $42.707 ($43.435); pay money (expenditures), $40.945 ($40.800).

The three military services will share as follows:

Air Force, $18.7 billion (only slightly less than in 1959); Army, $9.35 billion (up slightly from 1959); Navy, $11.37 billion (down $400 million from 1959); OSD, $1.4 billion (up $170 million from 1959).

Added to the Defense budget will be approximately $0.7 billion appropriated by Congress for 1959 but not spent. Of this, $308 million goes for one *Polaris* sub and one submarine tender. Another $300 million is added to the *Polaris* missile program. Also

DEPARTMENT OF DEFENSE FISCAL YEAR FY 1960 BUDGET SUMMARY (Millions of Dollars)

TITLE	DIRECT OBLIGATIONS [Buy Money]					EXPENDITURES [Pay Money]				
	TOTAL	ARMY	NAVY	AIR FORCE	OSD	TOTAL	ARMY	NAVY	AIR FORCE	OSD
OPERATING COSTS	22,477	7,114	6,088	8,492	783	22,319	7,108	6,025	8,407	780
MILITARY PERSONNEL	11,965	3,908	3,276	4,066	715	11,934	3,897	3,264	4,058	715
Active Forces	(10,642)	(3,514)	(3,164)	(3,964)	....	(10,617)	(3,506)	(3,152)	(3,959)	....
Reserve Forces	(608)	(394)	(112)	(102)	....	(602)	(391)	(112)	(99)	....
Retired Pay	(715)	....	....	....	(715)	(715)	....	....	....	(715)
OPERATION AND MAINTENANCE	10,512	3,206	2,812	4,426	68	10,385	3,211	2,761	4,349	65
CAPITAL COSTS	20,231	2,793	5,993	10,817	628	19,030	2,422	5,727	10,293	588
PROCUREMENT	14,919	1,373	4,747	8,799	....	13,938	1,209	4,504	8,224	1
Aircraft	(6,795)	(85)	(1,866)	(4,845)	....	(6,265)	(126)	(1,778)	(4,362)	....
Missiles	(3,764)	(406)	(658)	(2,700)	....	(3,825)	(463)	(593)	(2,768)	....
Ships	(1,719)	(5)	(1,714)	....	....	(1,659)	(2)	(1,655)	....	(1)
Other	(2,641)	(877)	(509)	(1,255)	....	(2,189)	(618)	(478)	(1,094)	....
RESEARCH, DEVELOPMENT, TEST AND EVALUATION	3,722	1,047	969	1,102	605	3,384	909	922	1,011	543
MILITARY CONSTRUCTION	1,589	374	277	915	23	1,708	304	301	1,058	45
Active Forces	(1,519)	(336)	(266)	(894)	(23)	(1,644)	(267)	(291)	(1,041)	(45)
Reserve Forces	(70)	(38)	(11)	(21)	....	(64)	(37)	(10)	(17)	....
REVOLVING AND MANAGEMENT FUNDS	....	....	....	....	....	—405	—266	—155	—25	42
TOTAL	42,707	9,907	12,081	19,308	1,411	40,945	9,264	11,596	18,675	1,410

benefiting are KC-135 jet tankers, $55 million; strategic airlift, $140 million; *Hound Dog*, $48 million. The solid fuel ICBM *Minuteman* gets $90 million plus a 40% program increase.

Senator Henry M. Jackson (D-Wash.) told m/r *Minuteman* would get $251,200,000 from AF's fiscal 1960 budget.

- **New levies**—In the budget message the President made several proposals for new taxes, among them:

Raise motor fuel tax to 4½ cents per gallon, bringing in an estimated $690 million the first year and $900 million the second.

Raise aviation gasoline tax to 4½ cents per gallon and levy a new 4½-cent tax on jet fuel, bringing in about $85 million the first year and $100 million the second.

He requested authority for item veto of legislation including authority to reduce the amount of an appropriation as well as to strike out an item. He noted that the Presidents of both parties starting back as far as Ulysses S. Grant have recommended this.

Regarding the missile and space field, the President said:

"For the fiscal year 1960, research and development expenditures will be increased still further, with emphasis on space exploration, peaceful use of atomic energy and basic science. Extensive space exploration investigations are being initiated, utilizing satellites and probes. Development work is going forward on high energy fuel rockets, a million-pound thrust engine and a nuclear rocket engine.

"The Department of Defense will significantly increase expenditures for procurement of missiles and for development and evaluation of new weapons, while reducing expenditures for other procurement and for construction."

- **More bases?**—The first hint that the U.S. is concluding negotiations with Italy (or another NATO country) for use of the *Jupiter* IRBM came in the President's statement: "The first units of the IRBM *Thor* have already been deployed to the United Kingdom and additional units of both *Thor* and *Jupiter* will be deployed during the next 18 months."

The President said that in view of negotiations with Russia for suspensions, the budget does not provide for any nuclear weapons tests in Fiscal 1960. Testing grounds in Nevada and the Pacific will be kept on a stand-by basis, he said.

According to the message, the first operational *Atlas* missile will be at launching sites by June 30, 1959. Later in the budget book (Page 474) was the statement:

"Missile capability in the strategic forces will be strengthened by the activation of the first wing of strategic missiles." The Air Force declined comment, but it is assumed that this new strategic wing—which must be composed of the ICBM *Atlas*—will replace a wing of obsolescent B-47 bombers. (The Air Force drops from 105 to 102 wings, a reduction of one tactical and two air defense wings, during 1960).

- **Progress report**—The message noted that:

The first five submarines equipped to carry the *Polaris* will go into operation during Fiscal 1960 (although the solid fuel *Polaris* itself is considerably further off).

The liquid fuel ICBM *Titan* is coming along at a "rapid rate."

Development work is "progressing rapidly" on the second generation solid fuel ICBM *Minuteman.*

Production of the air-to-ground *Hound Dog* has been accelerated for the B-52.

The anti-ballistic missile *Nike-Zeus* is being accelerated.

The solid fuel *Pershing* and *Sergeant* missiles will replace the old liquid fuel *Redstone* and *Corporal* missiles.

No more appropriations are planned for *Jupiter* and *Thor* IRBMs after 1960 unless they are desired by our allies. (1960 money is sufficient only to carry out the earlier planned program.)

Construction is underway on a new ballistic missile early warning system.

Air Force interceptor squadrons, in addition to *Falcon* and *Sidewinder*, will be partially equipped with the nuclear

NASA APPROPRIATIONS SUMMARY

	FISCAL YEAR 1959		FISCAL YEAR 1960
	APPROPRIATED	SUPPLEMENTAL ESTIMATES	REGULAR ESTIMATES
Salaries and Expenses	$ 83,100,000	$ 3,354,000	$ 94,430,000
Research and Development	50,000,000	20,750,000	333,070,000
Construction and Equipment	48,000,000	24,250,000	57,800,000
TOTAL APPROPRIATIONS	$181,100,000	$48,354,000	$485,300,000
Transfers from Department of Defense	$154,619,532	....	....
TOTAL NEW APPROPRIATIONS	$335,719,532	$48,354,000	$485,300,000

NASA R&D PROGRAMS—Fiscal Years 1959 and 1960

PROGRAM	FY '59 (In millions)	FY '60
AIRCRAFT, MISSILE AND SPACECRAFT RESEARCH (Support of NASA plant, JPL plant, and research contracts)	$ 13.995	$ 33.026
SCIENTIFIC INVESTIGATIONS IN SPACE (Sounding rockets, earth satellites, lunar probes, deep space probes, Vanguard program)	110.563	118.344
SATELLITE APPLICATIONS INVESTIGATIONS (Meteorology, communications)	8.100	28.000
SPACE OPERATIONS TECHNOLOGY* (Manned space flight, space rendezvous techniques)	37.661	73.000
SPACE PROPULSION TECHNOLOGY (Solid fuel rockets, high-energy fuel rockets, 1-million pound single-chamber engine, nuclear rocket engines, space engines, auxiliary power units)	29.000	64.200
SPACE SYSTEMS TECHNOLOGY (Advanced vehicle systems, booster recovery systems, orbiting space laboratories)	1.000	5.000
SUPPORTING ACTIVITIES (Tracking and data acquisition)	4.300	11.500
TOTAL PROGRAM	$204.619	$333.070

* Supplemental Estimate, FY '59—$20.750

ARPA R&D OBLIGATIONS

PROGRAM BY ACTIVITIES	1958 ACTUAL	1959 ESTIMATE	1960 ESTIMATE
1. Military sciences		$ 13,700,000	$ 18,000,000
3. Missiles and related equipment	$ 1,238,389	80,000,000	128,100,000
4. Military astronautics and related equipment	13,236,576	331,726,000	307,000,000
8. Programwide management and support	1,041,229	1,900,000	1,900,000
TOTAL OBLIGATIONS	$15,516,194	$427,326,000	$445,000,000

armed air-to-air rocket, the MB-1 *Genie.*

More than 70 *Nike-Ajax* and *Nike-Hercules* ground-to-air missile battalions will be in operation by the end of Fiscal 1960. These are in addition to an unnamed number of the longer-ranged *Bomarc* squadrons.

Work will continue at about the same level as in 1959 on the development of a nuclear powerplant for military aircraft.

The last of the old B-36 bombers in the SAC inventory will be replaced by B-52s armed with the *Hound Dog.*

The first B-58, intermediate range Mach 2 bomber, will be introduced into the SAC inventory.

- **NASA and ARPA**—The NASA budget for 1960 is $485,300,000 of which only $333,070,000 is for actual research and development, the remainder earmarked for salaries, construction and equipment. This $333 million must encompass all R&D work, including a fair portion not directly related to space work.

The ARPA budget is $455 million, including administration and certain research activities not connected with space work.

In addition, the Secretary of Defense has an emergency fund of $150 million to exploit breakthroughs in any field. It might or might not be used for space—might or might not be used at all. The AEC is included in the space budget for an unnamed amount, possibly for the nuclear rocket engine, but certainly a small sum.

The figure listed for overall space projects by the administration is, as noted previously, $830 million. Stripped of administrative and other details, the actual figure probably would more nearly approach $700 million for the entire national space program. There undoubtedly will be fringe benefits from research and developments of the services. The budgets of NASA, ARPA and Defense Department R&D are made out differently and cannot be compared in detail.

This is an explanation of the programed activities included in the ARPA breakdown, and to some extent that in R&D:

- **Military sciences**—Basic research in the physical and life sciences; applied research of importance for military purposes, operations research, and development of new materials, components and techniques.

Examples: radio astronomy, thermoelectric materials, masers, neurosensory phenomena, blood substitutes, boundary layer control and hydrofoils.

- **Missiles and related equipment**—Research, development, test and evaluation of strategic, tactical, air defense, and special purpose missiles, test vehicles and related equipment, including an extensive research and development effort on new techniques.

- **Military astronautics and related equipment**—The conductor programs directed at improvement of space technology for military purposes and the investigation of specific military applications of space vehicles. These include reconnaissance, communications, navigation and early warning of ballistic missile attack.

- **Program management and support**—The operation, management and maintenance of research, development and test facilities.

- **NASA program**—The NASA program for 1960 is aimed at improving design and performance of virtually all types of flight vehicles. Projects include:

Research on stability, control and similar problems encountered in a wide range of flight regimes from relatively slow take-off speeds to extreme conditions encountered by ballistic missiles, hypersonic aircraft, orbital vehicles and spacecraft.

Research on high energy rocket engines and fuels, on nuclear power for propulsion and ion and plasma propulsion systems for spacecraft.

Research on the response of structures and materials to environments imposed by flight at various altitudes and speeds.

Research on such problems as icing, turbulence, noise and fire in manned space craft operations.

Development of optimized satellite payloads, systems studies of spacecraft and overall control of satellite and space probe launching and tracking.

TOTAL R&D ESTIMATES FOR 1960

	IN MILLIONS		
	1958 ACTUAL	1959 ESTIMATE	1960 ESTIMATE
Research, development, test and evaluation appropriations	$2,502.7	$3,521.9	$3,722.4
Development, test, and evaluation support included in procurement appropriations	1,656.1	1,821.7	1,843.4
TOTAL, research, development, test, and evaluation including procurement support[1]	4,158.7	5,343.6	5,565.8

[1] Exclusive of military pay and military construction.

This table includes individual appropriations of the three military services, ARPA and the Defense Secretary's emergency fund.

In 1960 for the first time, figures for research and development will incorporate also the cost of tests and evaluation, which heretofore had been included in production and procurement costs. This will tend to make the R&D figure significantly higher and should reduce correspondingly the P&P funds. This table is for direct R&D obligations, that is, money which can be contracted for—buy money.

MISSILE EXPENDITURES LARGEST

Broken down by category, the Defense research, and development and evaluation figures on missiles and related equipment is three times as large as any other category.

SUMMARY OF PROGRAM BY ACTIVITIES	IN MILLIONS		
	1958 ACTUAL	1959 ESTIMATE	1960 ESTIMATE
1. Military sciences	$ 344.4	$ 360.3	$ 371.9
2. Aircraft and related equipment	442.5	472.6	487.3
3. Missiles and related equipment	904.3	1,341.8	1,437.6
4. Military astronautics and related equipment	17.4	345.9	309.1
5. Ships and small craft and related equipment	132.1	158.7	167.7
6. Ordnance, combat vehicles, and related equipment	179.1	188.8	235.0
7. Other equipment	323.6	379.9	430.8
8. Programwide management and support	135.1	137.8	133.0
9. Emergency fund and expired accounts	34.2	136.1	150.0
TOTAL DIRECT OBLIGATIONS	$2,502.7	$3,521.9	$3,722.4

Here's 1959 Outlook for Missile Materials

Metals will remain the mainstay, but competition from plastics will mean more teaming with ceramics

by Alfred J. Zaehringer

DETROIT—Following last year's missile materials review (m/r, March, 1958), many laboratory items have entered the missile field as standard production items. During 1958, many new materials have appeared, and still other materials and techniques now shaping up point to expanding missile and space horizons. Many missilemen find it hard to keep in step with the ever-increasing tempo, which will continue—further complicated by hybridization or merging of fields and materials. This article will attempt to boil these down and present some highlights of the 1958 missile materials megamania.

- **Metals**—They continue to be the mainstay of the missile business. Plastics have started to take a chunk of this business and, as a result, metals have teamed up with ceramics (particularly ceramets and ceramic coatings) to push forward the use range beyond the common 1600-1800F of ferrous alloys. Some of the high spots of 1958 in the metals field include:

- **Aluminum**—With a primary metal capacity of about two million tons per year, aluminum remains king of the light metals. Aluminum-lithium alloys are now battering at the thermal barrier of high supersonic aircraft and missiles. Alloys 5052 and 5454 are suitable for continuous temperatures of 200-400 F. Recently, foamed aluminum with a specific gravity of 0.1 (2.7 for regular Al) seems to open new missile structural applications. Aluminum also is seen gaining in nuclear reactor use and will probably be applied in atomic rockets. Aluminum remains an old faithful for shipping concentrated hydrogen peroxide and fuming nitric acid.

- **Lead**—The king of shielding materials, lead took a significant new step ahead in 1958. The USSR Central Research Institute of Ferrous Metallurgy claims it has made the "impossible"—a true alloy of steel and lead—by ultrasonic production techniques. If true, the report will mean an important structural and shielding material for atomic rockets.

A review of 1958 developments shows a wide variety of available missile materials—many of them unknown a few years ago. It is predicted that within 10 years, an entirely new spectrum of missile materials will be with the industry. Such materials, now mostly a gleam in the minds of scientists, engineers, and industry, will be able to continuously handle temperatures of 3000°F, offer high strengths, be light and corrosion-resistant.

The Editors

- **Magnesium**—Though strongly supported with good engineering data by the relatively small magnesium industry, this ultra-light metal has had rough going in aircraft since the last war. Missile applications exist but are small. Big bugaboo that "mag" has had to fight is relatively high cost and the contention that production is too small for widespread use in a strategic area. Still, Mg has found some entrance into the missile field in the form of powdered fuel for solid propellants. Magnesium alkyls could, it is felt, offer advantages over aluminum fuels such as the pyrophorics.

- **Molybdenum**—Reserves of moly are expected to last about 100 years at the present rate of use. Under welding conditions, moly has taken several steps forward by processing under argon or helium atmosphere and, with slight additions of carbon (0.4-0.6%) could significantly improve fabrication techniques. It has been suggested that protective coatings are mandatory for high-temperature oxidation resistance. Moly has a higher "useful" strength at temperatures of over 1600 F than most known materials.

- **Nickel**—This vital metal continues to play a major role in high-temperature metallurgy. Inconel X missile seals have operated at 6000 psi and 1200 F, and this metal is also being used on underwater missile powerplants. Alloys 4130 and 4140 reportedly have not been holding up well in rocket chambers and auxiliary systems. The action of fuming nitric acid on nickel and cobalt pumps has also been rough. Inco says free world nickel capacity by 1961 will be nearly 700 million pounds.

- **Niobium**—Missile and nuclear technology has caused a steady growth of this metal's production. Half the density of tantalum, niobium is looking up for high-temperature oxidation resistance (to its melting point of 4400 F) in rocket engines and other hot spots.

- **Platinum**—Long useful in missile electronics, contacts, etc. The Soviets claim they have put this costly metal to use—in solid form—in certain rocket engine applications where high-temperature oxidation resistance is needed.

- **Rhenium**—Rhenium-moly thermocouples can be used to 3200 F and rhenium-tungsten alloys could push this application to over 4000 F for use in reducing (non-oxidizing) atmospheres.

- **Stainless Steel**—Missiles and the nuclear fields are large consumers of stainless steels. Missile acceptance of the AISI 200 types of stainless (manganese substituted for part of the nickel in the familiar 18-8) types could be significant. Stainless steels have shown promise in handling the white-fuming nitric acid rocket propellants. High-temperature strength research continues and several interesting combinations have turned up. AISI 400 alloys are good for applications in the 600-1400 F range while iron-base alloys (15-20% Cr and 27-32% Ni) have been developed for severe conditions. A new precipitation-hardened stainless PH 15-7 Mo (15% Cr, 7% Ni, 2.5% Mo, and 0.09% C) is suggested as a possible substitute for titanium in supersonic environments.

- **Tantalum**—High corrosion resistance (melting point 5300 F) continues to make this metal useful in electronics—particularly in miniature missile capacitors. The 1958 use of tantalum is estimated at a quarter of a million pounds.

- **Titanium**—With a sponge capacity of 27,000 tons per year, about 90-95% of U.S. titanium goes into supersonic vehicle skins, fasteners, and structural members. Crucible Steel recently introduced a heat-treated titanium skin alloy with a strength of over 250,000 psi. Much work is shaping up to determine the corrosion-resistance of titanium to the rocket oxidizer red-fuming nitric acid. Manganese in the alloy or inhibiting with copper sulfate may eventually make itanium a good bet for a red-fuming nitric acid rocket tank of light weight and high strength.

Scaife Company is considering the use of titanium for rocket casings. Titanium Metals Corp. has an alloy (TI-155-A) which has a strength of 170,000 psi.

In summary, ferrous alloys (see Acme-Newport Steel Co. cover photo) will hold sway over the light metals for rocket construction. Recognizing heir limitations above 2000 F, however, rocket makers will move to the exotic metals such as protected moly, with more and more "rare" metals (such as zirconium, tantalum, and niobium) finding extensive use for high-energy rockets systems dictated by luorine, hydrogen fuels, and the "hot" solids.

Beyond the rare metals, wedding of ceramics (see table) and metals may push long-term operation to 5000-7000 F. Even beyond this, it is conceivable that a complete hybridization of all materials—metals, ceramics, and plastics—into one homogeneous "super material" will provide the ideal rocket substance: metals for high strengths at low temperatures and for shock resistance, ceramics for temperature resistance, plastics for flexibility and fatigue-resistance, and fibers for multidimensional stability.

Indeed, researchers are already pointing a way to the "plasticeramet." For example, silicon is a well-known constituent of metals. Silicon oxides, coupled with silicon polymers and quartz fibers could, some blue-sky scientists say, be "alloyed" with certain metals to form "plasticeramets"—the ideal container which can hold the long-sought "universal solvent."

- **Non-metals**—It is probably a safe bet that non-metals have made a startling rise in our technology spectrum. Contrasted to the metals which were known to primitive man, most non-metals of rocket interest today are, at the most, only several hundred years old. Non-metals have not helped metals pass the 1600-1800 F use range but are now actually challenging metals at the 2000-4000 F range. An example of this is the current parallel development of the ablating non-metals contrasted to the high-heat capacity heat sink metals. Some of the non-metal developments during the last year:

- **Ceramics**—Growing missile applications (see table) include use of such materials as glass, refractories, cermets, and ceramic coatings. One dramatic ceramic application was the Rokide A (aluminum oxide) coating on the nose cone and shell of the *Explorer* satellite. Alternating stripes of this material kept instrumentation at a temperature of 50-86 F. Ceramic-coated moly rocket nozzles were able to take 3000 F under oxidizing conditions for 7-8 hours. Zirconium and thorium oxides are already being sought for temperatures above 5000 F. Plastification of brittle ceramics appears to portend an eventual new class of missile materials which can, like metals, take high thermal shocks.

- **Elastomers**—Much elastomeric work is now concerned with the evolution of new solid propellant fuel-binders and fluorine- or ozone-resisting materials. New fields, such as inorganic elastomers, are expected to evolve. Promising inorganic elastomeric systems might hinge on lithium, beryllium, boron, magnesium and aluminum compounds that are now rare laboratory curiosities.

- **Fibers**—Teflon fiber bags already are being used to hold concentrated oxidizing acids and may be used in expellant bags and for pre-packaged liquid rockets. Big fiber increase was glass fibers which hit a production of about 160 million pounds. Very considerable amounts go into reinforced plastics with missiles taking a good share. Carborundum's Fiberfrax (aluminum silicate) fiber can take continuous temperatures of 2000 F. Carbon Wool can take temperatures of 5400 F. Quartz fibers have hit a tensile strength of nearly 400,000 psi and appear to offer this strength for long periods at 1800 F.

- **Plastics**—Structural plastics appeared on both the *Explorer* and *Vanguard* satellites. Missiles such as *Titan, Terrier,* and *Sidewinder* are said to make extensive use of plastics. Nearly 200 million pounds of reinforced plastics were turned out—most of them thermosets.

MATERIALS OUTLOOK IN BRIEF

METALS

- **Aluminum . . .**
  good high-temperature characteristics keep it king among light metals, likely to be used in atomic rocket.
- **Lead . . .**
  tops for shielding. Soviet claim of steel-lead alloy might spell use in atomic rockets.
- **Magnesium . . .**
  winning consideration as powdered fuel for solid propellants.
- **Molybdenum . . .**
  a superior material at high temperatures, with touch of carbon it might be used to improve fabrication.
- **Nickel . . .**
  used in missile seals and underwater powerplants, reportedly suffers in rocket chambers.
- **Niobium . . .**
  production growing, looking toward use in rocket engines.
- **Platinum . . .**
  costly but useful; Russians claim they've used it in rocket engines.
- **Rhenium . . .**
  could be alloyed with tungsten for use in reducing atmospheres.
- **Stainless steel . . .**
  now heavily used in missile and nuclear fields, it is subject to much research aimed at improving high-temperature performance.
- **Tantalum . . .**
  high corrosion resistance makes for continued use in electronics.
- **Titanium . . .**
  most U.S. output already goes into missiles. Alloy may be used for red-fuming nitric acid rocket tank.

NON-METALS

- **Ceramics . . .**
  missile uses growing; plastification may lead to metal-like shock-resistance.
- **Elastomers . . .**
  much work aimed at evolving solid propellant fuel-binders and fluorine- or ozone-resisting materials. New fields likely, including inorganic elastomers.
- **Fibers . . .**
  Teflon bags now used to hold concentrated oxidizing acids, may be used in expellant bags and for pre-packaged liquid rockets. Various fibers can take high temperatures.
- **Plastics . . .**
  already in structural use in satellites and missiles. Work continues to develop strength and durability at high temperatures.

RAYTHEON

New Navy missile now with Flee

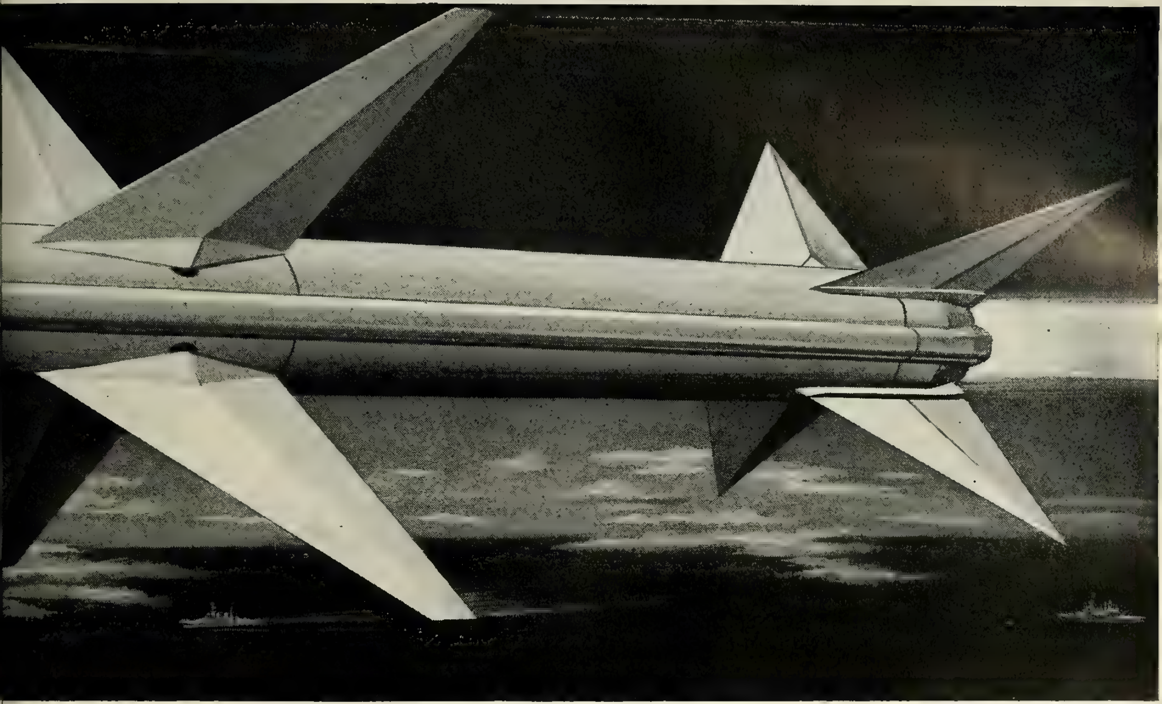
Sparrow III is tenacious, accurate, lightning-fast. It uses a unique "wide-angle" radar target seeker which permits Navy pilots to launch missile from almost any approach angle and still score a hit. Once locked on target, Sparrow III guides itself, flying at several times the speed of sound, and unerringly intercepts the hostile aircraft despite evasive action.

Now operational aboard Navy carriers, Sparrow III is slated for fighter squadrons throughout the Fleet. The missile is designed and produced for extreme reliability; has a powerful warhead and all-weather capability.

Raytheon is prime contractor for the Sparrow III, under the Navy's Bureau of Aeronautics. This new missile is another example of how the 37,000 men and women of Raytheon are contributing to national security.

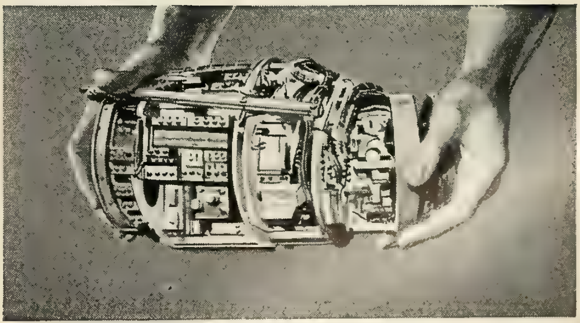
RAYTHEON SPARROW III weapon system employs n "wide-angle" radar. Navy pilot can launch missile from alm any angle and hit the target. Missile guides itself automatica relentlessly destroys enemy aircraft in spite of evasive tact

SPARROW III



uides itself, out-thinks target

V BEING DELIVERED to the Fleet, Sparrow III arms the st Navy jet fighters. This new rocket-powered missile is ly reliable, has all-weather capability. It is extremely accu- and carries a powerful warhead.



SELF-CONTAINED electronic brain developed by Raytheon and the Bureau of Aeronautics guides Sparrow III. This 12-ft. long, 8 in. diameter missile is engineered for high reliability and ease of operation in shipboard use.

RAYTHEON MANUFACTURING COMPANY, Waltham, Mass.

RAYTHEON

Excellence in Electronics

RADIOPLANE RP-76 SIMULATES NEAR-SONIC ENEMY ...ARMY MISSILEMEN SCORE HIT IN FIRST FIRING!

Place: Red Canyon Range, New Mexico. Time: minutes after an RP-76 high-altitude air-launching by Radioplane personnel. Event: Army missilemen sight RP-76 simulating an enemy weapon system approaching at Mach 0.9. They fire—for the first time against an RP-76—score a direct hit.

Responsible: the men of Battery C, 1st Missile Battalion (Nike-Ajax), 56th Artillery, U.S. Army Defense Command; the men of Radioplane's contractor-operated flight service program, backed by the more than 2,500 Radioplane drone specialists who designed and produced the RP-76.

This Army-Radioplane achievement typifies the result of Radioplane teamwork with all of the U.S. Armed Forces. Other current examples in development: the supersonic USAF-XQ-4A weapon evaluation target drone and the U.S. Navy's XKD4R-1 rocket target, two more members of Radioplane's complete drone family.

RADIOPLANE
VAN NUYS, CALIFORNIA, AND EL PASO, TEXAS
A Division of Northrop Aircraft, Inc.

Circle No. 23 on Subscriber Service Card.

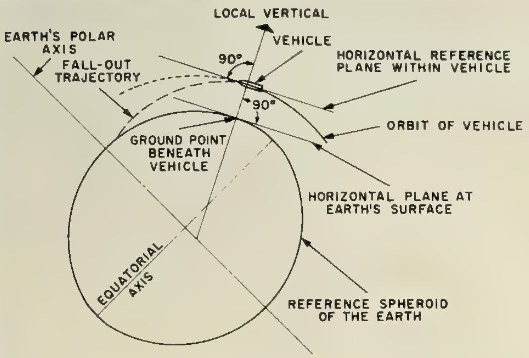

LOCAL VERTICAL
EARTH'S POLAR AXIS
VEHICLE
FALL-OUT TRAJECTORY
90°
HORIZONTAL REFERENCE PLANE WITHIN VEHICLE
90°
ORBIT OF VEHICLE
GROUND POINT BENEATH VEHICLE
HORIZONTAL PLANE AT EARTH'S SURFACE
EQUATORIAL AXIS
REFERENCE SPHEROID OF THE EARTH

FIG. 1

Re-entry Navigation: 'Breakthrough' Is Not Required

by Raymond M. Nolan

WASHINGTON—The re-entry navigation problems of space vehicles and satellites can be solved today—without any major new breakthroughs—by use of horizon scanning with infrared means, according to a Sperry scientist.

The opinion was delivered by E. J. McCartney of Sperry Gyroscope in a paper at a recent meeting of the American Astronautical Society. McCartney urged use of the earth's horizon as a vertical reference for the re-entering body. He discussed the problems of detecting the horizon by infrared methods and indicated possible performances.

- **The problem**—Basis of the problem which McCartney proposes to solve is the need for a stable vertical reference or local vertical. The local vertical is the line which is normal to the surrounding earth's surface beneath the vehicle; it is the line perpendicular to the earth's reference spheroid at a point where the outward extension of the line passes through the vehicle. The local vertical (shown in Fig. 1) defines the ground point which is directly beneath the vehicle and establishes the direction of up or down.

Space vehicles have two uses for the local vertical: positioning the retrojets to produce the ballistic fallout path and, once within the atmosphere, manipulating the vehicular control surfaces to maintain a glide path toward the desired landing point.

One method of sensing the local vertical is to use the gravity vector, whose direction closely coincides with the direction of the local vertical, i.e., the gravity vector also is perpendicular to the surface of the reference spheroid. However, use of the gravity vector to establish the local vertical fails in the case of an orbiting satellite or a re-entering vehicle because they are partly or completely weightless. In this state, the gravity vector within the vehicle either vanishes or diminishes so greatly that it loses its reliability in the presence of other disturbances.

McCartney recognizes the availability of inertial guidance as a solution to this problem but claims that the inclusion of a system which can continuously extrapolate the direction of the local vertical from launching to final point is self-defeating. The size of a passive terminal guidance reference from the initial launching guidance, he says, would require an expensive, complex and heavy system, involving many instrumental uncertainties.

- **The earth itself**—But, says McCartney, the surface of the earth itself, seen from a proper vantage point, is a gravity reference completely unaffected by any motions of the vehicle. The mean free surface of the ocean, an equipotential surface, is everywhere perpendicular to the gravity vector and for centuries has been used as a vertical reference in measuring celestial altitudes with the marine sextant. Also, the rim of land surface, even when broken by mountains, approximates a vertical reference when viewed from a sufficient height. Scanning by infrared methods would provide both day and night operation during almost all types of surface weather.

The geometry of horizon-scanning is shown in Fig. 2 with the vehicle assumed to be at an altitude of 200 miles. The horizon is sensed at point "A" by moving the field of view of one infrared detector up and down in the plane of the diagram so that the detector is first looking out into space just above the horizon and then looking at the earth's surface just below the horizon. The thermal discontinuity or radiation gradient at the horizon provides the phenomenon to be detected. Scanning the horizon at diametrically-opposite point "B" furnishes another tangential line. Bisection of angle AOB by instrumentation establishes a plane normal to the earth's surface at point Q; line PQO is the edge-trace of this plane.

The plane then provides a reference for pitch control of the vehicle. When the horizon is scanned at two additional diametral points, 90 degrees around from points "A" and "B," and the resulting tangential lines bisected, a second normal plane is produced for controlling the roll attitude of the vehicle. According to McCartney, these two planes, normal to the earth's surface and perpendicular to each other, intersect along line PQO which becomes the direction of the desired local vertical within the vehicle.

Using the author's example, for a vehicle altitude of 200 miles, the horizon lies all around at a slant range of 1300 miles, not allowing for refraction. The depression angle to the horizon is 18.2 degrees. At the slant range of 1300 miles, a 2-mile mountain will subtend an angle of about 5 minutes of arc. However, since mountain ranges usually occupy only limited horizontal angles, errors can be substantially re-

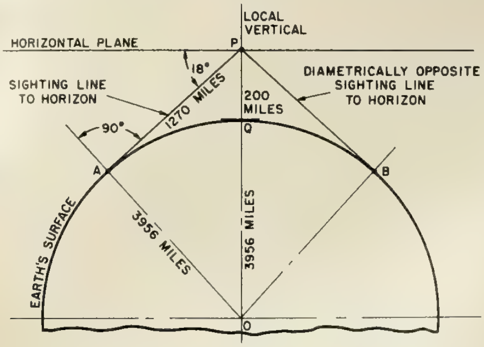


FIG. 2

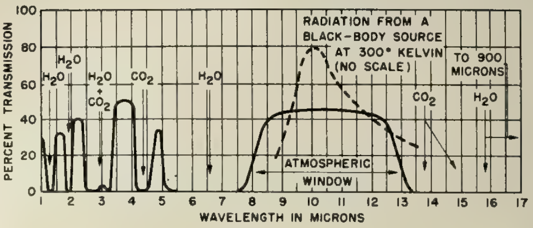


FIG. 4

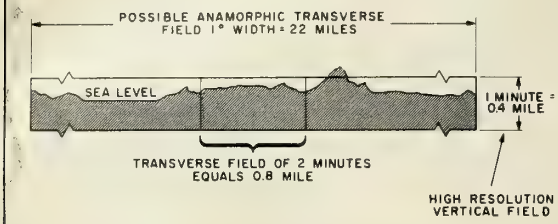

POSSIBLE ANAMORPHIC TRANSVERSE FIELD 1° WIDTH = 22 MILES
SEA LEVEL
1 MINUTE = 0.4 MILE
TRANSVERSE FIELD OF 2 MINUTES EQUALS 0.8 MILE
HIGH RESOLUTION VERTICAL FIELD

FIG. 3

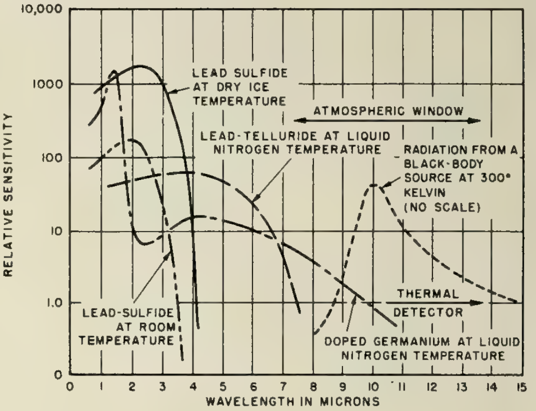


FIG. 5

HORIZON-SCANNING geometry is illustrated at top left. Lower left figure illustrates the averaging effect possible with proposed method using broad lateral field to average terrain irregularities. Illustration at top right shows infrared absorption at sea-level. Lower right hand diagram contrasts various types of infrared detecting elements.

duced by employing a field of view whose lateral extent is much greater than the vertical.

This tends to give an averaging effect as shown in Fig. 3. McCartney says an anamorphic type of optical system might have some value here, accepting a wide lateral field of view with resultant lateral compression of the image and allowing use of a smaller area detector.

Several things affect the performance of the proposed system. They can be roughly grouped into natural factors and instrumental factors. The author further divides natural factors into the earth-surface horizon and the atmospheric horizon.

- **Natural factors**—When the earth's horizon is scanned vertically by a thermally-sensitive infrared receiver having a small vertical field of view, a radiation temperature increment averaging several degrees C exists. Slope and amplitude are functions of local meteorological conditions at the horizon. The gradient is steep enough to permit an infrared receiver with a small vertical field of view and with a response peaked around 300 degrees Kelvin, to resolve the horizon line to within a few minutes of arc.

Some of the problems in discerning the thermal horizon formed by the earth's surface are caused by attenuation of radiation by absorptions due to carbon dioxide and water vapor and by scattering due to haze, fog and cloud particles. Unfortunately, the particles, in addition to scattering the desired radiation out of the sighting path, also scatter unwanted radiation into the path.

Wavelengths from 7 to 14 microns—the atmospheric window—seem to provide a good region of operation since these wavelengths take in the bulk of radiation from a 300-degree Kelvin source (fig. 4). However, the sides of this window close in with increasing amounts of water vapor along the sighting path.

Absorption bands are another consideration. If all-weather operation is required, the effects of scattering by atmospheric particles are important. When the wavelength is great compared to the particle size, the scattering varies inversely as the 4th power of the wavelength. Haze particles with a diameter of 1 micron or less are not as important as fog and cloud particles with a diameter of 20 to 60 microns.

McCartney holds some hope for all-weather capabilities by going to the very long infrared wavelengths of 1 millimeter and greater. He says that although much less energy is radiated along these wavelengths, the earth-sky contrast is not necessarily made worse. He adds that Sperry is currently conducting a research program in connection with the detection of these millimeter waves.

The atmospheric horizon is another factor. McCartney compares the troposphere and the atmosphere and says that the troposphere is probably acting as a good radiator. Seen in great optical depth, it is no doubt radiating as a black body at the shorter wave

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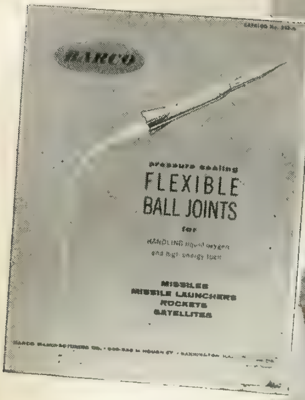
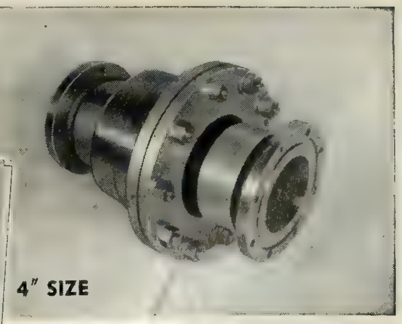
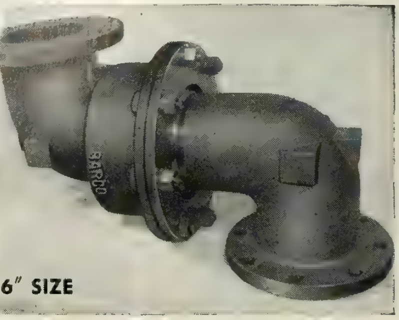




4" special stainless steel Barco Flexible Ball Joint for handling liquid oxygen.



180° flanged 6" Barco Ball Joint for use in loading and unloading line handling liquid propellant.

. . . . liquid oxygen, white fuming and red fuming nitric acid, and JP 3, 4, and 5 fuel

–special designs for LOX and other Missile Fuels

Extensive design and manufacturing experience is yours to call upon at Barco for the handling of special liquid fuels in the aircraft, rocket, and missile industries:

—Flexible Ball Joints for metal loading lines handling corrosive fluids.

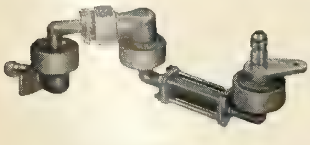
—Special flexible joints with leakproof seals for conveying fluids at low temperatures down to −300°F. Also high temperature designs up to +1000°F.

—Special designs resistant to nuclear energy radiation.

Barco joints provide flexibility *unlimited* for piping and tubing. Our engineers will be glad to work with you on special problems and assist with recommendations.

ASK FOR NEW BULLETIN No. 233-A

Flexible Hydraulic Lines for Missiles, Aircraft



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Barco produces high pressure self-aligning swivel joint and tubing assemblies for hydraulic pressures to 4,000 psi, and higher. Also a wide selection of standard and special swivel joints and assemblies for launching and flight gear. Sizes ¼" to 1".

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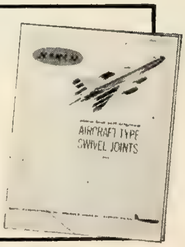

BARCO *Serving Industry Since 1908* AIRCRAFT DIVISION
MANUFACTURING CO., 566B Hough St., Barrington, Ill.

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absorption bands and also over the spectral expanse from 14 to 900 microns. In contrast with the stratosphere which emits very little self-radiation, he sees the tropopause as a usable horizon for an infrared detector. The disadvantage exists, however, of establishing a new horizon once the vehicle has descended below the tropopause.

- **Instruments**—In the category of instrumental factors, McCartney contrasts photoconductive elements with thermal detectors. Of the photoconductive elements, only lead sulfide attains high sensitivity without cooling—but its response does not extend to the longer wavelengths. Of the refrigerated detectors, he says, only doped-germanium reaches the atmospheric window from 7 to 14 microns with any response (see Fig. 5).

Thermal detectors such as the thermopile, bolometer and Golay cell respond less to shorter wavelengths but maintain flat response over a broad region. The Golay cell is still a usable detector up to 1 millimeter. The time constant of the Golay cell is only 5 to 10 milliseconds, but McCartney claims that this is adequate since the field to be scanned is small and the relative angular velocity between vehicle and horizon is not great.

Window materials are the final factor that McCartney considers. He assumes that the scanner window will be about 3 to 4 inches in diameter. He discounts rock salt, potassium bromide and KRS-5 for various reasons such as fragility, susceptibility to moisture and difficulty of fabrication in the required size. He says silver chloride would be adequate with a suitable coating.

Astronautics Tests

Jan. 14—*Hawk* fired at White Sands made direct hit on 1400-mile-an-hour *Q-5* target missile.

Jan. 15—*Bomarc* launched from Eglin AFB in the first missile test from the operational training facility. Missile made direct hit on jet drone 87 miles away.

Jan. 15—*Atlas* travels less than 200 miles in 18th flight test. Range destructed when engine system malfunctioned.

Jan. 18—Chance Vought "battlefield mobility concept" missile—*Project Firepower,* fired successfully at Redstone Arsenal.

Jan. 19—*Polaris* AX-4 fired. First described as "fully successful" later, termed "partial success."

STEPS IN THE RACE TO OUTER SPACE

Mars Snooper

This nuclear-fueled reconnaissance craft is preparing to land on Mars' outermost satellite, Deimos—12,500 miles away from the "red planet" (center) and 35 million miles away from the Earth. Deimos' gravitational pull is so slight that a featherlight landing could be made, and a take-off could be accomplished with little more than a shove of the pilot's foot! (At Deimos' orbital speed, such a push would start the ship back to Earth at 3000 miles per hour.)

Our spaceship is designed to fly in two directions—nose first as a space rocket and tail-first as a ramjet airplane. Propulsion for both is provided by a single atomic heat source, reacting with hydrogen for rocket thrust, and with atmosphere to power the ramjets.

Travel to Mars, braking for landing, take-off and re-entry are accomplished by rocket-thrust. As the ship approaches the Earth's atmosphere, it assumes a tail-first attitude. The "petal doors" enclose the rocket nozzle, and the ship is transformed into a high speed, ramjet airplane with M-shaped wings. Control fins are located in the nose of the craft, near the crew's quarters.

ENGINEERS • SCIENTISTS

ARMA needs key men to augment a broad research program in missile guidance and space technology. As designer and developer of all-inertial navigation systems for TITAN and ATLAS ICBM's, ***ARMA*** provides a stimulating atmosphere where creative talents can develop. Write to E. C. Lester, Professional Placement, MR-I ***ARMA*** Division, Garden City, N. Y. A Division of American Bosch Arma Corporation.

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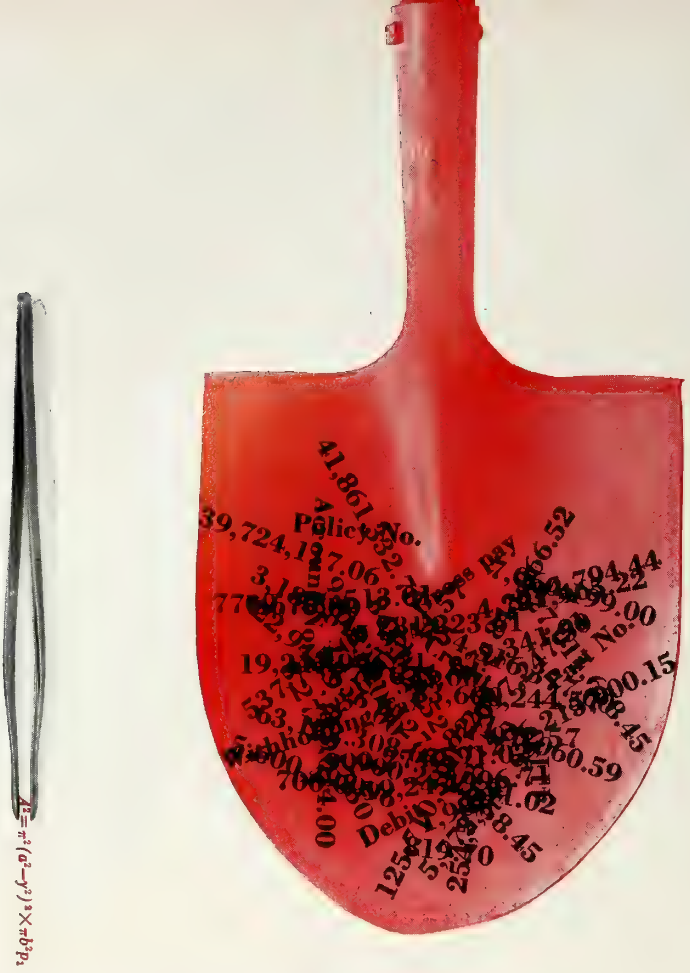
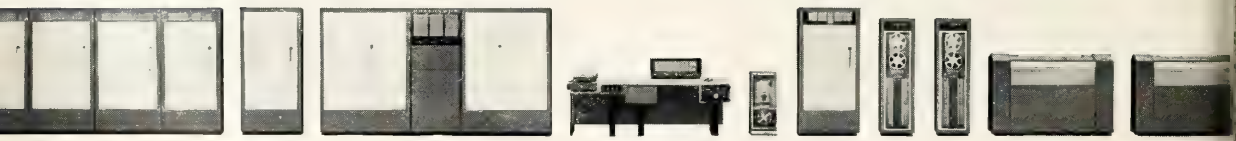


does both jobs equally well—Burroughs 205 Computer



From the sequential solution of long scientific problems to the mass processing of business data, the versatile Burroughs 205 electronic data processing system is ideally suited to a wide range of applications. Top capacity and speed in the medium price class, complete choice of input-output media, vast external magnetic tape storage. At work in many varied industries, the 205 has proven its superior dollar-for-dollar value. Its flexibility lets you grow into a larger Burroughs system as your needs increase. Burroughs extensive support program provides on-the-spot technical assistance for an advanced and complete line of data processing systems...all currently in production. Write for 205 brochure. ElectroData Division, Pasadena, California.

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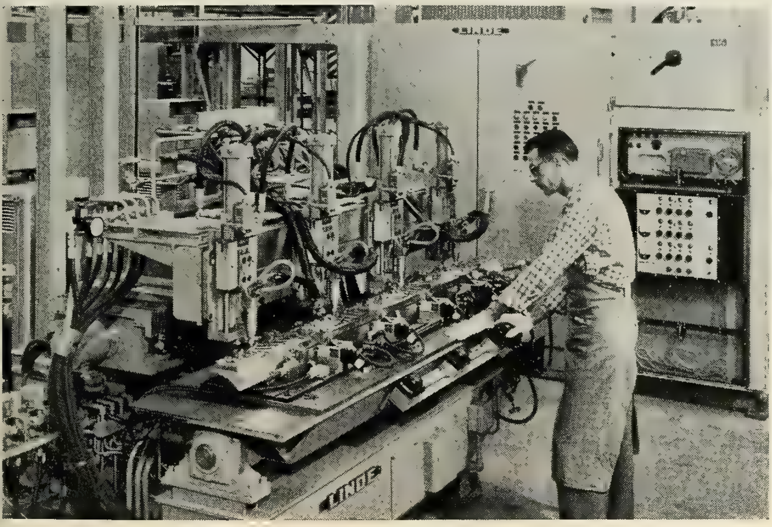
Multiple Welds Produce 'Problem' Parts



A tape-controlled, multiple-torch Heliarc spot welding machine, invented and developed by **Linde Co.,** Div. of **Union Carbide Corp.,** is being used by Convair Div. of General Dynamics Corp. to produce "problem" parts for *Terrier* surface-to-air guided missiles.

Convair engineers ran into production problems on some *Terrier* parts, such as control and dorsal fins, because they could be welded from only one side. Since conventional resistance spot welding techniques require that both sides of a joint be accessible, it was impossible to use these methods.

Heliarc spot welding, however, requires access to only one side of the joint. Welds are produced by a tungsten electric arc, shielded by inert argon gas. Since the heat of the arc melts the metals through the joints, the second side of the joint need not be accessible. Heliarc spot welding thus is ideal for joining parts in which two or more surfaces must be welded to a core.

The process utilizes positive and instantaneous arc ignition. This starting system eliminates all high-frequency interference problems and avoids the contamination problems of retract starting. Electrode life is increased by a factor of four over high-frequency starting and process reliability is greatly increased.

Convair contracted with Linde to design and construct a tape-controlled programmer and welding machine that could produce up to four identical parts at one time. The machine has four torches, arranged so four parts may be welded simultaneously. Hydraulic controls position the torches horizontally and they are raised and lowered pneumatically.

Under subcontract to Linde, two other firms supplied parts for the Convair installation. The Welding Machine Division of Expert Tool & Die Company supplied mechanical and hydraulic components, while a punched-tape program control unit was supplied by Farrand Controls Corp.

Circle No. 225 on Subscriber Service Card.

Multi-Use Piston Hydraulic Pumps

A new line of constant pressure, variable displacement, piston type hydraulic pumps, specifically developed for high-temperature applications in aircraft and missile hydraulic flight control systems, is now available from **Pesco Products Division, Borg-Warner Corp.**

The new pump design features increased reliability at higher operating speeds, insensitivity to type of fluid used, high-temperature bearings, all-metallic O-rings and seals, and a minimum of rotating parts.

Available with either single or dual pumping elements, the pumps are designed to run at speeds up to 7500 rpm. The pumps are recommended for use with fluid temperatures up to 550F and ambient temperatures up to 600F.

The new line of variable delivery piston type units cover a range of capacities from 3 to 27 gpm, when operating at rated speed. System pressures for these capacities are generally 3000 psi, although some pumps, such as the dual unit type, are used in 4000 psi systems.

Circle No. 227 on Subscriber Service Card.

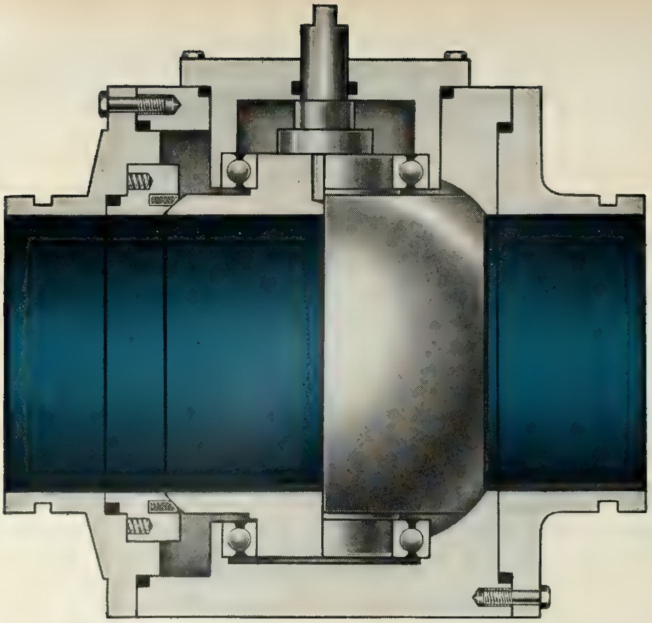
Electrolytic Capacitors Have Long Shelf Life

Aluminum electrolytic capacitors, designed for miniaturized electronic equipment, have been developed by **P. R. Mallory & Co. Inc.,** which dubbed them the "PET" series. The new line uses a new low-resistance electrolyte which gives long shelf life at temper-

NOTE: *For additional information about any product mentioned in this section of Missiles and Rockets use the attached prepaid reply cards. Circle numbers shown on the reply card that correspond with numbers appearing beneath items described. If no circle number accompanies the article or advertisement, give page number (and advertiser's name) on line provided at bottom of the card.*

Your requests for information will be forwarded promptly to the companies concerned.

The Editor



HYDROMATICS *FLO•BALL*® VALVES

The accepted standard of maximum performance and reliability

100% FLOW EFFICIENCY

Hydromatics' exclusive FLO•BALL design provides a straight-thru unrestricted fluid path, exactly equal to the pipe line diameter.

PERFECT SEALING

Zero leakage is assured through the use of a precision ball—the ideal geometric form for perfect sealing contact.

LOW OPERATING TORQUE

Ball rotates in precision bearings which absorb all pressure loads. Pressure balanced valve seat further minimizes forces on ball, reducing frictional drag.

LONG LIFE

Seat is always in sealing contact with the ball surface, resulting in a self-wiping, self-lapping action that insures long, trouble-free life.

HIGH SPEED ACTION

Only 90-degree rotation is required to fully open or close valve. Full travel as fast as 5 milliseconds.

RELIABILITY

Simple construction, with only one rotating part, provides built-in reliability and rugged, dependable operation.

CRYOGENIC AND CORROSIVE APPLICATIONS

Hydromatics' FLO•BALL valves, with new diaphragm sealing and unrestricted fluid path, have been proved the best valves for operation with LOX, Liquid Nitrogen, Helium, Hydrogen Peroxide, Red Fuming Nitric Acid and Hydrazine.

MODULAR ARRANGEMENT

Only FLO•BALL design, with its rotating valve action, permits side-by-side grouping of several valves, all driven simultaneously by a single actuator.

VERSATILITY

Only FLO•BALL design makes possible the interchanging of manual, motor or pressure actuators without changing the valve body.

HYDROMATICS, the world's leading designer and manufacturer of high performance ball valves for military and industrial applications, offers the most extensive selection of designs to meet all your requirements; Manual, motor or pressure operated. For cryogenic, corrosive or general service media. Pressures from vacuum to 10,000 psi. Sizes from ¼ inch to 12 inches.

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atures up to 85°C. The new design produces stability of capacitance—variation from −30° to +85° is within the range of −15% to +10%.

The new capacitors provide more capacity for their size than other comparable aluminum electrolytic. Maximum capacity in the 5/8" by 1" case size ranges from 550 microfarads at 3 volts to 86 microfarads at 50 volts.

Two designs available are the printed circuit model in single, dual and triple ratings for vertical mounting; and the axial lead design for printed circuit and other electronic applications, available in single and dual ratings.

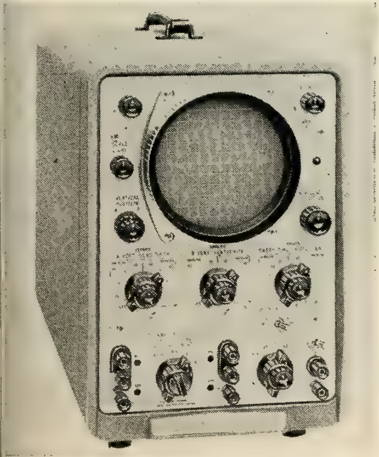
The series covers a temperature range of −30°C to +85°C, and has a capacity tolerance at 25°C of −10% to +250%. The units are encased in plastic with an epoxy end-seal. The sizes vary from 3/8" x 5/8" to 5/8" x 1 7/8". Ratings cover voltages from 3 to 50 WVDC, and capacities of 1500 to 1 microfarad total per unit.

Circle No. 234 on Subscriber Service Card.

200 KC Oscilloscope Has Twin Amplifiers

A new 200 KC oscilloscope with dual trace presentation is now available from the **Hewlett-Packard Company.**

The instrument, Model 122A, has twin vertical amplifiers and a vertical function selector. The amplifiers may be operated independently, differentially on all ranges, alternately on successive sweeps, or chopped at a 40 KC rate.



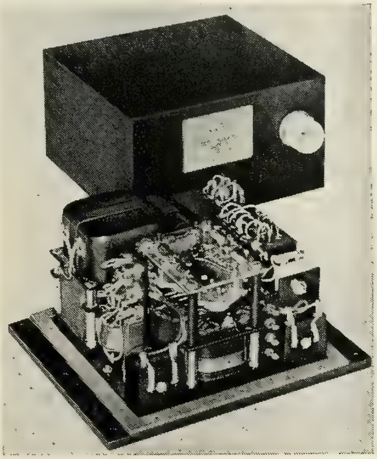
Model 122A triggers automatically and has a maximum sensitivity of 10 mv/cm. One knob selects any of 15 calibrated sweeps from five microseconds/cm to 200 milliseconds/cm in a 1-2-5 sequence. Sweep accuracy is ±5%.

Other features include a "times-5" sweep expander which provides maximum speed of 1 microsecond/cm on the 5 microsecond/cm range. Trace normally runs free, syncing automatically on 0.5 cm vertical deflection, but a knob adjustment eliminates free-run and sets trigger level as desired between −10 and +10 volts.

Circle No. 232 on Subscriber Service Card.

Static Power Inverter Has 20,000-Hour Life

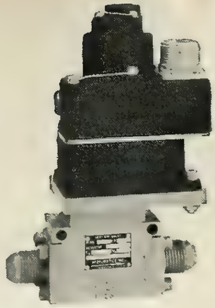
A solid state static power inverter, utilizing transistor and magnetic amplifier circuitry to convert an 18-30 volt dc source to an 115 volt, 400 cycles per second, single phase ac source, has been developed by **Magnetic Amplifiers, Inc.**



Designed to produce a stable power output of 80 VA, the unit was created for use in missiles, aircraft and ground equipment, and has other applications in automation, atomic energy programming, and ignition systems. Its output is stabilized in voltage and frequency for wide variations of input voltage, load, load power factor and ambient temperature.

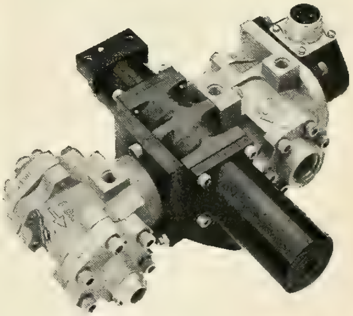
The power inverter is said to have a life expectancy of 20,000 hours under continuous operation, in comparison with the nominal 2,000-hour life of conventional generators. It has no moving parts or bearings to lubricate, functions noiselessly, and contains no vacuum tubes.

Vibration range of the unit is from 10 to 2,000 cycles. It withstands high shock to 30 times its weight, and will not spark at any altitude. It will withstand variable input voltages up to 40



½" MOTORIZED FLO•BALL VALVE
100% flow efficiency — for general service media up to 3000 psi

Extremely light weight and compact, suitable for a wide range of aircraft and missile applications, both airborne and ground support. Provides perfect sealing and 100% flow efficiency for general service media (jet fuels, hydraulic fluids, water, alcohol, helium, hydrogen, oxygen, etc.) at pressures up to 3000 psi and temperatures from —65° to 200°F. The DC motor actuator includes automatic current shut-off and a positive Geneva-Lock mechanism. Valve is of bi-stable design — in the event of electrical power failure, the valve will remain in its last position, either open or closed. Included is a built-in microswitch for remote observation of valve position. Flanges, which are removable and interchangeable, may be specified per AND-10050, AND10056, NPT or ASA.



FLO•BALL PROPELLANT VALVE
Dual line flow control of cryogenic media at 1000 psi

For simultaneous flow control of Liquid Oxygen and Fuel, this prop valve provides zero leakage control of a ⅝" LOX line and ½" Fuel line at pressures up to 1000 psi and temperatures as low as —350°F. A single-acting, spring-return pressure actuator drives a precision mechanical linkage which controls both valves, thus insuring constant timing. The valves are extremely fast acting, with response times as short a 10 milliseconds. All dynamic sealing is double with a vent between seals for maximum safety. A sealed, rotary action snap switch permits remote observation of valve position. Valve flanges, available in standard or special styles, are removable and interchangeable.

Hydromatics, Inc.

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Among the wide variety of heating blankets and woven-wire heating elements successfully engineered by SAFEWAY to meet tailor-made specifications are:

- **heating blankets for honeycomb and metal-to-metal bonding**
- **de-icing units for airfoil surfaces**
- **heating elements for launching equipment and for airborne gyros, cameras, computers, servos and batteries — for missiles or aircraft**
- **radiant heating panels for industry**
- **defrosting units for industrial and commercial refrigeration**

FOR YOUR COPY OF A FACT-FILLED FOLDER, PLEASE WRITE:

Safeway HEAT ELEMENTS INC.

680 Newfield Street • Middletown, Connecticut

If it has to be heated (and the "it" can be just about anything), you can rely on SAFEWAY engineers to study your problems and — without any obligation — submit an appropriate recommendation.

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volts and may be repeatedly switched on and off without generating frequency transients or malfunctioning.

Built according to military specifications, the static power inverter includes such features as an output of 115 volts, adjustable to plus or minus 5%; output frequency of 400 cycles per second, plus or minus 1%, regulation of 1½% for load variations from no-load to full-load; power factor of minus 0.5 to plus 0.5; maximum distortion of 5%; and ability to operate in ambient temperatures ranging from –55°C to +71°C.

Another feature of the component permits manual adjustment of output from 105 to 125 volts and frequency control in a range of plus or minus 3 cycles per second.

Measuring 4 in. in height, 6 in. in width, and 6 in. in length, the static power inverter weighs 10 lb.

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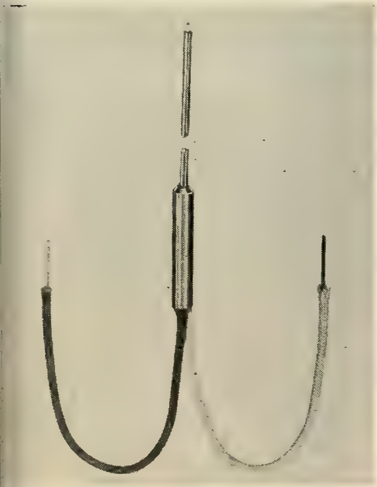
Thermocouples Made by Con-P-Pak Process

Con-P-Pak thermocouples are designed to meet the severe demands required of controls and instruments



used in rocket engines, melting furnaces, nuclear reactors and in the processing of liquid hydrogen, alcohols and other materials difficult to handle. A number of metal combinations are used, such as copper-constantan for temperatures down to –300°F and rhodium platinum for temperatures over 1600°F.

The thermocouples are made according to the new Con-P-Pak process with conductors encased in specially processed ceramics and surrounded by chemically clean metal sheaths. Various junctions and tips are available as well as several connectors.

Insulation resistance between wires and sheath ranges up to 100 megohms at 500 V.D.C. and dielectric strengths to 2000 V.A.C.

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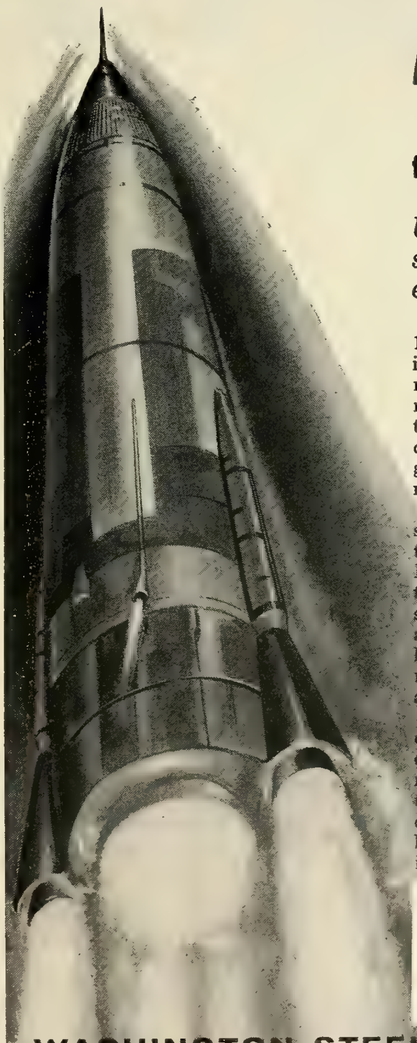
Tiny Hydraulic Pump/Motor Operates at 24,000 RPM

Now available for all aircraft and missile installations requiring a smaller, lighter pump or motor in hydraulics systems, the "Hummingbird," a new 24,000 rpm, miniature, piston-type hydraulic pump/motor has been recently introduced by **Borg-Warner's Pesco Products Div.**

Performance runs of 50 hours at 24,000 rpm have been made, with the pump delivering 2.5 gpm at 3000 psi. No appreciable loss in efficiency has been shown at the end of these runs.

The Hummingbird pump/motor features spherical piston rings, all-metal O-rings and seals, a new type of universal joint, and all-steel construction.

The pressure-locked spherical piston rings maintain high efficiency through-



MicroRold® stainless steel soars with

ATLAS ICBM

on first full range flight!

U. S. missile program one step nearer to complete operational capability.

On the evening of November 28, 1958, a 100-ton ATLAS lifted from its pad at Cape Canaveral and arched majestically into the heavens. 30 minutes later its nose cone shot into the Atlantic, marking the first successful completion of its fully-programmed distance of 6300 statute miles.

The main part of the ATLAS structure is literally a huge fuel tank, the shell of which is thin gauge MicroRold stainless steel. Important factors in selection of stainless steel for the outer skin of the ATLAS are—great strength at both high and low temperatures, resistance to corrosive exotic fuels and good workability.

The stainless skin, supplied exclusively by Washington Steel, requires extremely close control of mechanical properties and gauge tolerance which are regularly produced through Washington Steel's long experience with precision rolling equipment.

NOW IN ORBIT!

4½ ton third stage
118 to 625 mile altitude
December 18, 1958

WASHINGTON STEEL CORPORATION
1-H WOODLAND & GRIFFITH AVENUES
WASHINGTON, PA.

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out operating life. They minimize possibility of seizure due to fluid contamination, thermal shock, or cylinder distortion, and eliminate side-load wear.

Metallic O-rings and seals, coupled with all-steel construction of the Hummingbird pump/motor, allow operation of the unit with fluids of temperatures from –65° to 550° F. This universal joint has three equally spaced rollers attached to each end of the universal shaft, transmitting the drive rotary motion smoothly and uniformly at all speeds.

Weighing 1.1 pounds in a steel body 4.125 inches long, with a displacement of .025 cubic inches, the Hummingbird may be operated in either rotation. No modifications or adjustments are necessary for its installation as a pump or as a hydraulic motor. It may be run directly from high speed turbines or similar drives.

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Small Solid Batteries Deliver 1600 Volts

A group of solid state batteries, small enough to hold in the palm of your hand but capable of delivering a combined voltage of 1600 volts, are now available from **Patterson, Moos Division of Universal Winding Co.,** Jamaica, N.Y.

The batteries, called "Dynox", come in four different sizes—Dynox "95",

with a 95 volt potential in 0.14 cubic inches, Dynox "190," with a 190 volt potential in 1.15 cubic inches, Dynox "380," with a 380 volt potential in 1.57 cubic inches, and Dynox "950," with a 950 volt potential in 2.87 cubic inches.

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Lox Pump Motor Delivers 60 gal/min.

Recently developed by the J. C. Carter Co. for pumping liquid oxygen of liquid nitrogen is an electric motor driven two stage centrifugal pump. Designed to deliver 60 gallons per minute against a 550 ft. head, this pump is particularly suited for installations where light-weight, compact design is important.

Circle No. 229 on Subscriber Service Card.

Electrically Isolated Telemetry Amplifier

Endevco Corp. offers a new airborne subminiature amplifier, Model 2617, to be used with high impedance transducers such as piezo-electric and capacitive devices. When used with Endevco accelerometers and Endevco Model 2980 insulated mounting studs, the complete system is electrically isolated from ground. The Model 2617 is protected against humidity (potted).

It offers compact design features: 1000 megohm input impedance with less than 50 mv residual noise (shorted input), broad range of 2 cps to 20 kc and low current requirement (5.0 milliamps). The amplifier is 7.5 cubic inches in volume and weighs 7 ounces.

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SPACE

Cape Canaveral is the site of the nation's major terminus to space. This terminus is managed by Pan Am. Our Guided Missiles Range Division has prime responsibility for management, operation and maintenance of the 5000-mile Atlantic Missile Range extending from Florida through the Bahamas to Ascension Island and beyond.

Because of these operations and the division's dynamic growth, we can offer high level physicists, mathematicians and electronic engineers truly unique opportunities in missile test and space probe engineering.

For an investigation of your future in the space age with Pan Am, please address a confidential resume to Mr. C. R. Borders, Assistant Division Technical Manager, Pan American World Airways, Inc., Patrick Air Force Base, Cocoa, Fla., Dept. B-3.

PAN AM
GUIDED MISSILES RANGE DIVISION
PATRICK AIR FORCE BASE, FLORIDA

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250,000 impulses

instead of industry-recognized 100,000 cycles

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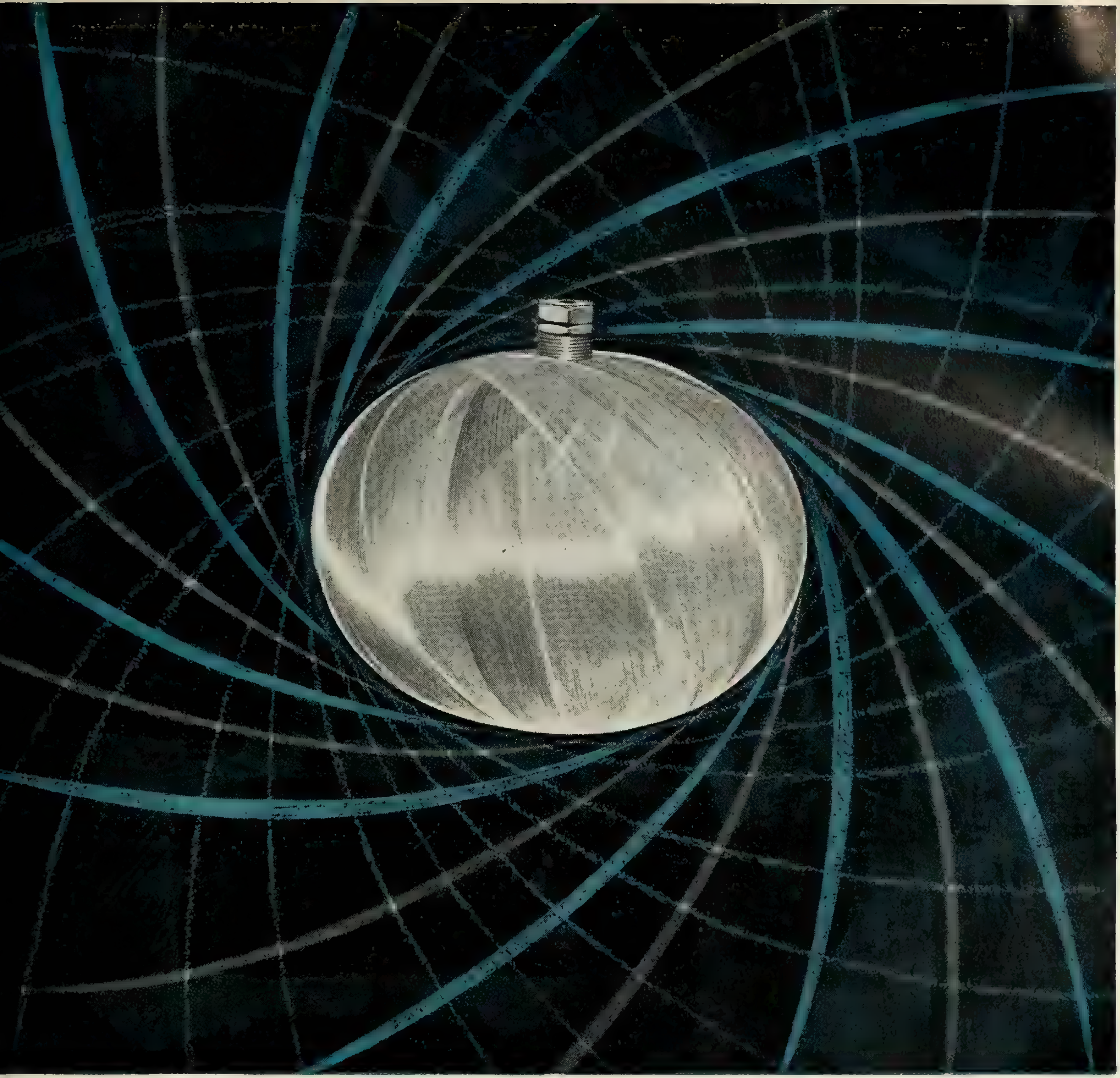

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Iere's the big news in the pressure essel field. Brunswick's new, nique Strickland "B" Process (SBP) ow results in filament-wound lastic vessels with the greatest trengths ever obtained. At the same ime, vessel weights have been drasically pared down. Brunswick can reate vessels (from that shown bove to air bottles and rocket motor ases) with these specifications: Hoop stress values in the range of 175,000 to 200,000 psi. Burst strength values: up to 150,000 psi. Weight: 20 to 40 per cent *less* than that of *any* previously built plastic vessels. Temperature limits: up to 600° F. Super tough SBP vessels are also ideal for components that must stand up to extended operating cycles, and can be mass produced in compound and monocoque shapes. For proposed or existing projects involving pressure vessels, Brunswick offers skillful assistance in the design, development and fabrication stages. For more details concerning the higher strength—lower weight advantages of SBP components, write or call: The Brunswick-Balke-Collender Company, Defense Products Division Sales Manager, 1700 Messler St., Muskegon, Michigan.

BRUNSWICK

MAKES YOUR IDEAS *WORK*

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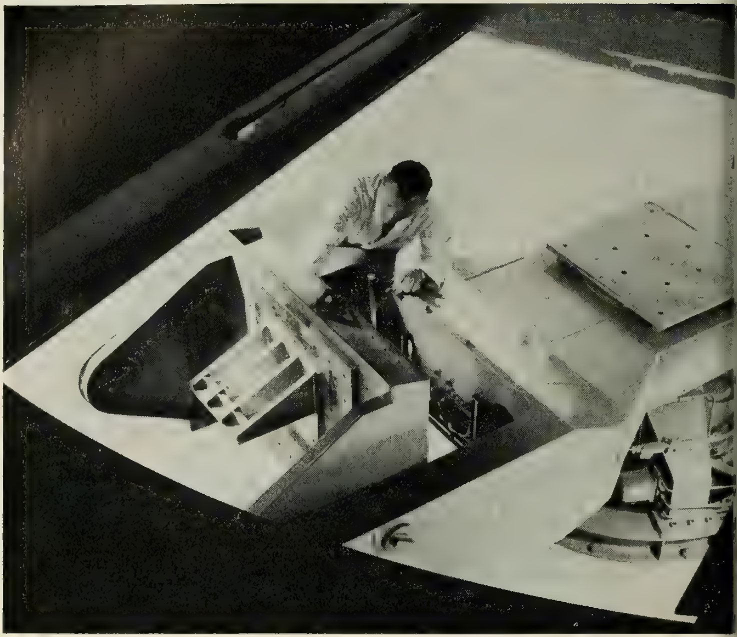
(left) Pop-up test of Navy Polaris IRBM.

(below left) One of the Santa Cruz test stands with dynamic thrust mount to simulate flight environment. Vibration oscillator functions during static firings.

(below right) Large centrifuge for environmental testing has unique shaker attachment to provide vibration simultaneously with high G-loadings.



EXPANDING THE FRONTIERS OF SPACE TECHNOLOGY

...Test

Testing is a vital part of every stage in the development of missile and space programs at Lockheed Missile Systems Division.

The Division maintains one of the most completely equipped missile and space test laboratories in the world. Equipment includes: altitude, temperature and humidity chambers; shaker and vibration systems; G-accelerators; and apparatus capable of performing chemical, metallurgical, plastic, heat transfer, hydraulic, pneumatic, shock, acceleration, sinusoidal and random vibration, structural, electrical, and electronic tests. Static field testing; research and development testing on controls; testing in ordnance and hydraulics and high-pressure gas and propulsion systems are conducted at the 4,000 acre, company-owned test base in the Ben Lomond mountains near Santa Cruz, California.

As weapons systems manager for such major, long-term projects as the Navy Polaris IRBM; Discoverer Satellite; Army Kingfisher; Air Force Q-5 and X-7; and other important research and development programs, Lockheed is engaged in expanding the frontiers of technology in all areas.

Flight testing is conducted at Cape Canaveral, Florida; Alamogordo, New Mexico; and Vandenberg AFB near Santa Maria, California; in a unique manner. All components and sub-systems of a new project are initially tested on known-performance, production missiles. Thus, when the final system is ready for first flight, its individual components already have flight-tested reliability. This new concept of flight testing is a major contribution and has enabled Lockheed to produce extremely complex missile systems in record time and at greatly reduced expense.

Underwater launch tests—including studies of cavitation, wave simulation and skip motion—are carried on at the Sunnyvale facility and at the Navy test base on San Clemente Island. In addition, structural and other tests are performed at Hunter's Point Naval Shipyard, California.

If you are experienced in any of the various phases of testing, we invite your inquiry. Positions also are available for persons experienced in physics, mathematics, chemistry, or one of the engineering sciences.

Write: Research and Development Staff, Dept. AAA-29, 962 W. El Camino Real, Sunnyvale, California; 7701 Woodley Avenue, Van Nuys, California; Suite 745, 405 Lexington Avenue, New York 17, New York; Suite 300, 840 N. Michigan Avenue, Chicago 11, Illinois.

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Circle No. 20 on Subscriber Service Card.

propulsion engineering

by Alfred J. Zaehringer

Stabilization of free radicals is being attempted at National Bureau of Standards. High concentrations of the large radicals (such as oxygen or nitrogen) apparently are easier to obtain than hydrogen. Percentages obtained so far are: hydrogen 0.01-0.1%, nitrogen 0.2-6%, and oxygen 1-16%. Adding inert atoms and storage in a strong magnetic field might increase percentages and effect stabilization.

Liquids to watch for 1959: nitrogen tetroxide and perchloryl fluoride for pre-packaged systems; liquid hydrogen for high performance systems; slight additional increase of fluorine use; LOX up slightly; peroxide about the same; nitric acid down.

Propulsion, according to John Sloop of NASA's Lewis Research Center, is the key to success in space flight. Propulsion always seems to lag behind vehicle development. Good example of our lag: U.S. moon probes and the recent Soviet moon shot. U.S. missiles tend to be underpowered; Soviets tend to throw in a little more power reserve.

Shrouded pulsejet engine, says the Air Force in one of its latest guided missile manuals, may be one way to extend the simple pulsejet into the supersonic operation range. Duct around engine keeps the air flow outside engine at low Mach number. It eliminates the pressure differences between ram pressure at the inlet valves and static pressure at the tail pipe exit.

Auxiliary power for space missions, ARDC estimates will be something like this during the next 10 years: 1 kw for hard impact on moon, 300 mile earth satellite, and circumlunar return; 1.6 kw for soft moon landing, landing on Mars or Venus, manned circumlunar and return, and controllable orbit satellite; 5 kw for manned space station; and 10 kw for roundtrip to Mars and Venus. Output of 7 kw/lb of generating equipment is acceptable for several years but this will have to improve later to 50-250 kw/lb.

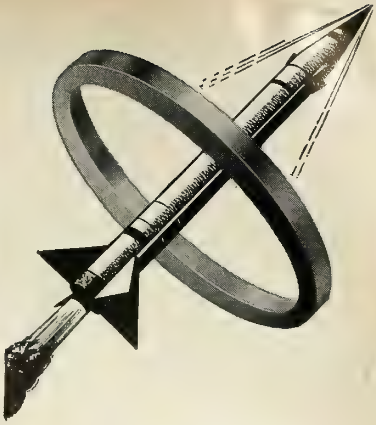
Ignition of solids is undergoing considerable research. Work in Zurich has shown that high intensity light can initiate detonations. At the University of Cambridge, electric fields have been used for ignition. On the other hand, neutrons, alpha particles, and other large fission fragments were not capable of producing ignition hot spots. At 10^4 roentgens, there is no great effect. To 10^7 roentgens only decomposition rates are changed. At Princeton University, shock waves have been used to ignite solid propellants (double base and composite). A helium shock wave of Mach 4 can ignite the solids. Aberdeen Proving Ground reports shock initiation of solids. University of Utah work outlines the transition from deflagration combustion to detonation when an inert solid medium interrupts deflagration.

Sweet propellants? Paris researchers have prepared sucrose (common sugar) nitrate. Properties indicate a low cost, high-energy solid propellant ingredient.

Ammonium nitrate can be used as an igniter material. Thiokol's Elkton, Md. Division has patented a starter-sustainer mix with AN, potassium dichromate, charcoal, and paraffin.

NOW WEEKLY COLUMN

With this issue of m/r, Propulsion and Chemistry Editor Alfred J. Zaehringer's column will be a weekly feature in response to requests of readers who desire more timely and interesting information in these fields.



How KENNAMETAL* Sealing Rings...

Help to Withstand High Temperatures . . . A jet engine shaft seal of Kentanium,* a titanium carbide, operating without lubrication at 15,000 surface feet per minute at 1000°F and 0.6 pounds pressure per lineal inch of circumference outperformed every other material tried. Kentanium is stress-free, dimensionally stable, maintains great strength and provides exceptional resistance to abrasion. It is providing all of these advantages on many applications . . . at temperatures up to 2000°F and as high as 5000°F for momentary service.

Help Solvent Separators to Resist Abrasion . . . On this job, Kennametal rings of Grade K96 were installed, replacing conventional seals which had at no time given more than two months' service and had sometimes failed in only 30 hours. Kennametal rings were inspected after six months in service, showed no perceptible wear and were returned to service. The customer predicts an ultimate service advantage of 50 to 1.

Help to Power Rockets . . . Here the sealing rings are used to handle red fuming nitric acid. After extensive testing of materials, rings made of Kennametal K501, a platinum-base composition, were chosen. The manufacturer reports: "Kennametal ring sealing results have been far superior to any other material with no indication of seal face wear." This was after the best life of the rings previously used had been exceeded.

For details, write for 24-page Booklet B-111, "Characteristics of Kennametal" . . . and 12-page Booklet B-444 which describes "Kentanium." KENNAMETAL INC., Dept. MR, Latrobe, Pa.

*Trademark 3172

INDUSTRY AND KENNAMETAL ...Partners in Progress

Circle No. 13 on Subscriber Service Card.

Operations Research

Mathematicians, Physicists and Engineers with experience or strong interest in Operations Research on large-scale automated systems will be interested in the major expansion program at System Development Corporation.

SDC's projects constitute one of the largest Operations Research efforts in the history of this growing field. The projects are concerned primarily with man-machine relationships in automated systems in a number of fields, including air operations. The application of new and advanced digital computer techniques is particularly important in optimizing these man-machine relationships.

Senior positions are among those open. Areas of activity include: Mathematics, System Analysis, Forecasts, Cost Analysis, Operational Gaming, Design Analysis, Performance Evaluation.

Those who have professional questions or desire additional information are invited to write Dr. William Karush, Head of the System Development Corporation Operations Research Group at 2414 Colorado Avenue, Santa Monica, California.

"A THEOREM IN CONVEX PROGRAMMING"
A paper by Dr. Karush is available upon request.
Address inquiries to Dr. William Karush at System Development Corporation.

SDC

SYSTEM DEVELOPMENT CORPORATION

Santa Monica, California

11-72C

west coast industry

by Fred S. Hunter

North American Aviation keeps making schedule on the *X-15*. The No. 2 vehicle is coming right along and will be ready for delivery shortly. No delays have been encountered in preparations for the first flight of the No. 1 aircraft. The Boeing B-52, modified to airlift the rocket craft under the wing, is at Edwards Air Force Base, flown over from Palmdale, and has been satisfactorily test-flown. Apparently, about the only thing that might cause any setback in the first flight would be water in the lake bed. The dry lake doesn't drain off very fast after a heavy rain.

Big engine—NAA's *X-15* schedule now calls for initial use of interim XLR-11 engines in the No. 2 aircraft, same as in No. 1. This means the first vehicle to make use of the higher-thrust XLR-99, designed for the *X-15* by the Reaction Motors Division of Thiokol Chemical Corp., will be the No. 3 aircraft, due in June. Retrofits of the No. 1 and No. 2 vehicles will follow. Necessity of using the lower-thrust rockets, designed originally by Reaction for the Bell *X-1*, is not expected to hold up the program. The XLR-11 in the eight-chamber rocket package worked out for the *X-15* is double the thrust of the *X-1* configuration, and does very well. It also looks as though everybody is satisfied with the progress being made on the high-thrust XLR-99, now on the test stand. The Rocketdyne backup project, initiated when XLR-99 dropped behind schedule, has been terminated as no longer necessary.

Losers learn—Watch for tighter, better bidding in the future as a result of the de-briefing program the Air Force set up for unsuccessful bidders in the *Minuteman* assembly and test competition. Those who lost out now know exactly why the award went to the Boeing Airplane Co. They also know where their own proposals fell short. So far as we know, this is the first time a military agency has provided the losers in a competition with a detailed picture of the step-by-step evaluation processes used in determining an award. The ballistic missiles groups headed by Maj. Gen. Bernard A. Schriever and Maj. Gen. Ben I. Funk have a good idea that should pay dividends down the road both for the Air Force and for industry.

New fields—Solar Aircraft Corp., which has made more than 4000 *Falcon* fuselages, *Nike* air vanes and some other missile components under subcontract, is submitting proposals for prime contracts on smaller missile systems as part of its program to accelerate its work in the missile field. It also is well into some phases of design and initial production of *Minuteman* solid-fuel rocket cases and accessories under subcontract to Thiokol Chemical Corp. To process rocket-engine assemblies made from new types of air-hardening steel alloys, Solar is installing a special 31x12-foot furnace at its San Diego bayfront leasehold. The maker calls it the world's largest atmosphere-controlled, heat-treat furnace.

Honeycomb progress—Northrop Division of Northrop Aircraft, which becomes the Norair Division of Northrop Corp. when the name change is made effective Feb. 2, represents another example of accelerating for missile and space work. It recently turned out the first large, stainless-steel, honeycomb panel following the installation of two production-brazing machines. "We intend to be ready for any job asked of us," said Manufacturing Vice-President Bob Lloyd. And, in his first management club address since becoming vice-president and general manager of the division, Dick Nolan reported: "We are definitely pointing toward space products. We have fine talent in this field—as good as any in the nation."

Electronics growth—With electronics sales for industrial and commercial use drawing ahead of sales of consumer items in 1958 for the first time, C. B. Thornton, President of Litton Industries, foresees the influence of electronics permeating every area of our economy, "making its presence felt just as electricity has done."

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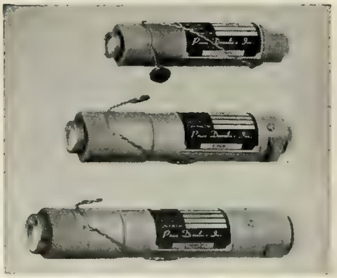

*MIL-V-8813 (ASG)
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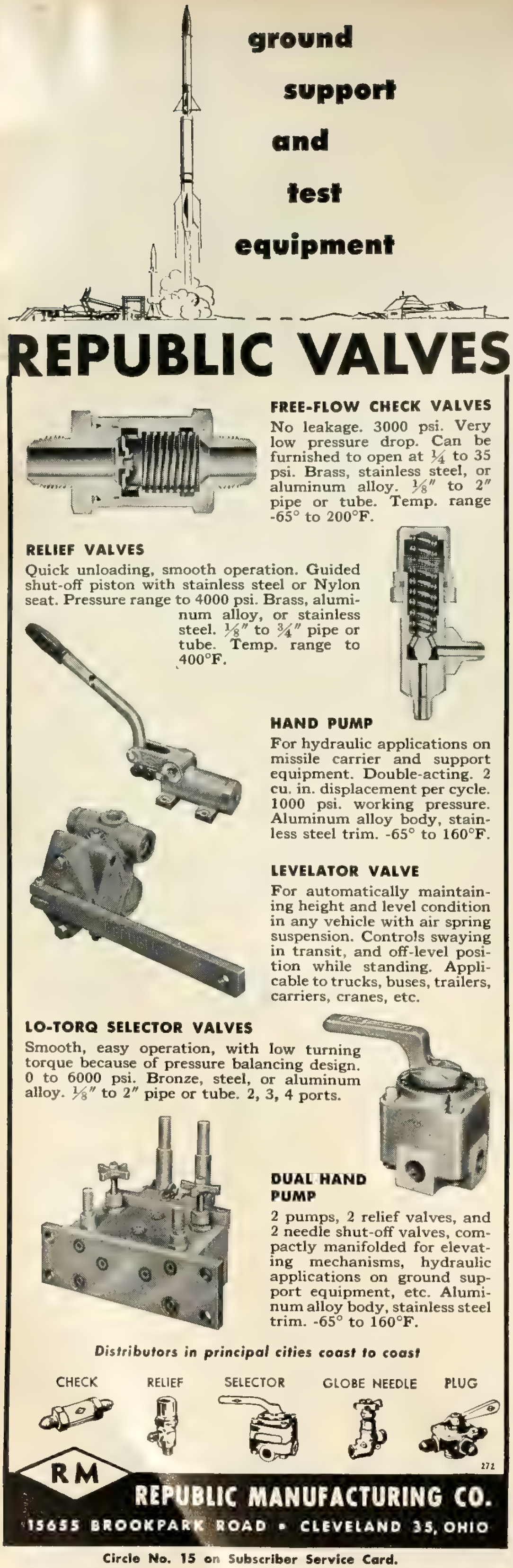
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HAND PUMP
For hydraulic applications on missile carrier and support equipment. Double-acting. 2 cu. in. displacement per cycle. 1000 psi. working pressure. Aluminum alloy body, stainless steel trim. -65° to 160°F.

LEVELATOR VALVE
For automatically maintaining height and level condition in any vehicle with air spring suspension. Controls swaying in transit, and off-level position while standing. Applicable to trucks, buses, trailers, carriers, cranes, etc.

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Smooth, easy operation, with low turning torque because of pressure balancing design. 0 to 6000 psi. Bronze, steel, or aluminum alloy. ⅛" to 2" pipe or tube. 2, 3, 4 ports.

DUAL HAND PUMP
2 pumps, 2 relief valves, and 2 needle shut-off valves, compactly manifolded for elevating mechanisms, hydraulic applications on ground support equipment, etc. Aluminum alloy body, stainless steel trim. -65° to 160°F.

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contract awards

ARMY

$5,866,290—**Firestone Tire & Rubber Co.,** Los Angeles, for *Corporal* system, (part of larger contract of $11,733,840 to be finished by Feb. 13, according to Ordnance Command). Apparently, subcontracts are: $570,000—**North American Aviation, Inc.,** for rocket engines; $236,396—**Topp Mfg. Co.,** Los Angeles, for transducers; $140,588—**Associated Aero Science Lab., Inc.,** Hawthorne, Calif., for technical assistance; $38,235—**Gilfillan Bros., Inc.,** Los Angeles, for repair parts; $34,995—**North American Aviation, Inc.,** for study relating to boundary layer surface material interactions.

$5,866,880—**Raytheon Mfg. Co.,** for engineering services and electronic components for *Hawk.*

$92,672—**Barnes Engineering Co.,** Stamford, Conn., for research in measurement of re-entry bodies of missiles.

$1,887,027—**Northrop Aircraft, Inc., Nortronics Div.,** for a prototype automatic test system for guided missiles.

$1,507,021—**Daniel Construction Co. of Alabama,** Birmingham, for construction of propellant development facilities (Thiokol) at Redstone Arsenal.

$245,296—**Butler & Cobbs,** Montgomery, Ala., for construction of engine development motor test facility at Redstone.

$386,698—**Douglas Aircraft Co., Inc.,** Charlotte, N.C., for *Nike* spare parts and components.

$347,492—**Western Electric Co., Inc.,** New York for *Nike* spare parts and components.

$200,000—**Emerson Electric Mfg. Co.,** St. Louis, for design and development of rocket motor.

$337,544—**The Cardan Co.,** Los Angeles, for missile assembly building at Vandenberg AFB.

$109,482—**Joseph F. Bester,** Riverside, Calif., for additions to building at Jet Propulsion Laboratory, Pasadena.

$41,455—**Michigan Tectronics, Inc.,** Detroit, for cable assemblies and ordnance parts.

$155,821—**National Co., Inc.,** Malden, Mass., for three engineering test models of Type "B" ground cesium atomic beam frequency standard, to be used by ABMA in connection with missile guidance.

AIR FORCE

$8,000,000—**Lockheed Missile Systems Div.,** Van Nuys, for continued testing of research vehicles in support of *Bomarc* program.

$1,600,000—**Northrop Aircraft Inc.,** Nortronics Div., for design and manufacture of a *Snark* proficiency trainer.

$932,870—**Yardney Electric Corp.,** New York, for *Bomarc* batteries (A Boeing subcontract.)

$700,175—**Boeing Airplane Co.,** Pilotless Aircraft Div., for technical data for *Bomarc* components (nine contracts); $135,975 for logistic depot in support of *Bomarc.*

$64,419—**Radiation Inc.,** Melbourne, Fla., for data transmission interconnection links.

$110,000—**Douglas Aircraft Co.,** Santa Monica, for engineering data, modification kits and spare parts for *Genie* rocket.

$40,264—**Graphic Films Corp.,** Hollywood, for production of color, sound film entitled "Astronautics."

NAVY

$2,000,000—**Collins Radio Co.,** Cedar Rapids, Iowa, for a high-density microwave system at the Pacific Missile Range.

$1,300,000—**Allen B. Du Mont Laboratories, Inc.,** for *Sparrow III* missile test sets. (Raytheon subcontract.)

$923,883—**Dale Benz, Inc.,** San Diego, **L. F. Stilwell & Co.,** Los Angeles, and **Cox Bros. Construction,** Stanton, Calif., separate contracts for construction at Naval Missile Test Facility, Point Arguello, Calif.

$648,015—**Wells Benz, Inc.,** San Diego, for construction of launch complex No. 1 at Naval Missile Test Facility Point Arguello.

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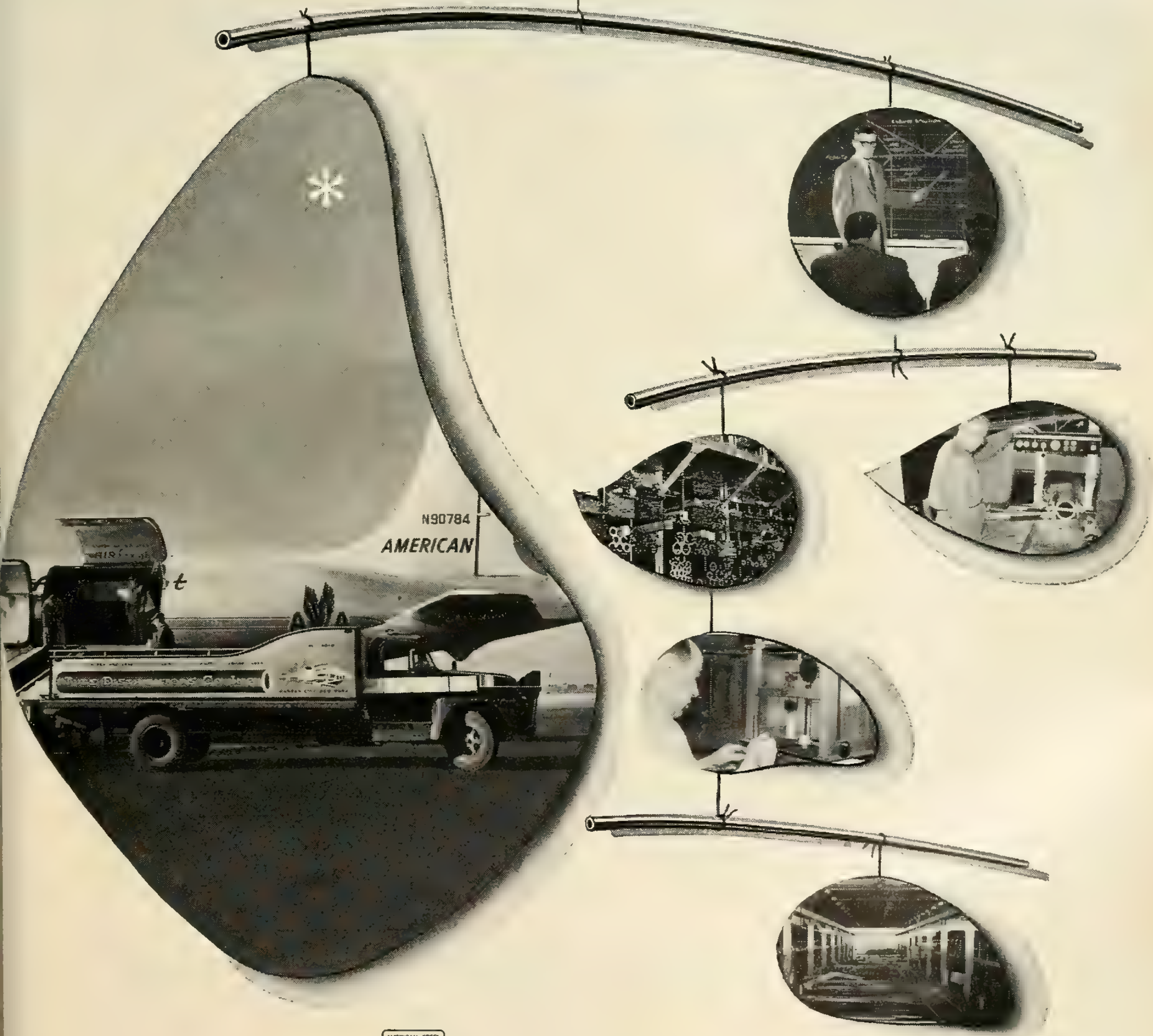

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missile people

John J. Crowley, former director of the Guided Missile Office of the Assistant Secretary of Defense for Engineering has been named vice president of the Grand Central Rocket Co. and will assume charge of project management. Crowley resigned from General Dynamics Corp. where he had been an executive assistant to the senior vice president for engineering.

Vice Admiral Charles B. Momsen (ret.) recently was named engineering consultant for the Bendix Aviation Corp. Adm. Momsen, known for his work on the "Momsen Lung"—a submarine escape device—will work on top-priority research and development programs.

Joseph E. Long, formerly Aerodynamic Research Supervisor, Navy Bureau of Ordnance, is now Aeronautical Research Engineer, Mechanics Division, Directorate of Aeronautical Sciences, Air Force Office of Scientific Research.

Cmdr. George Hoover, one of the country's early space flight exponents and prime mover of Project *Orbiter,* predecessor of the *Explorer* satellite, has left the Navy after 25 years to become director of technical planning for Benson-Lehner Corp., manufacturers of data processing machines. Hoover will have responsibility for 10-years-ahead technical development planning.

These appointments have been announced recently:

Garrison Norton, former Assistant Secretary of the Navy, as president of Institute for Defense Analyses.

Max Lehrer, specialist on Defense Department budgets, as assistant staff director of the Senate Committee on Aeronautical and Space Sciences.

J. R. Juncker as military relations engineer for the Semiconductor-Components division of Texas Instruments Inc.

Chance Vought Aircraft, Inc. has announced election of **Gifford K. Johnson** to the presidency of Genesys Corp., its new commercial electronics subsidiary in Los Angeles.

Vincent Prus is in charge of Goodyear Aircraft Corp.'s *Subroc* underwater guided missile production program.

Frank B. Jewett, Jr., has been elected executive vice president of Vitro Corp. of America, and **William B. Hall** was made a vice president of the corporation.

Carl G. Holschuh, executive vice president of Sperry Rand Corp. has accepted a one-year appointment to the governing Council of AOA.

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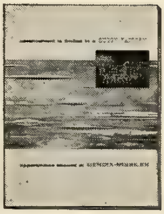

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Advertising correspondence should be addressed to Advertising Sales Manager, Missiles and Rockets, 17 East 48th Street, New York 17, N.Y.

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West Coast: 8929 Wilshire Blvd., Beverly Hills, Calif. Fred S. Hunter, manager; Walton Brown, regional adv. mgr.; James W. Claar, regional adv. mgr. Phones: OLeander 5-9161 or OLympia 7-1555.

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Canada: Allin Associates, 12 Richmond Street East, Toronto 1, Ontario. Phone: Harbour 6898. Allin Associates, 1487 Mountain St., Suite 4, Montreal, Que.

Geneva: American Aviation Pubs., 10 Rue Grenus, Geneva, Switzerland. Anthony Vandyk, European Director. Cable address: AMERAV GENEVA.

London: Norall & Hart Ltd., 28 Bruton Street, London W. I., England. Phone: Grosvenor 8356.

Paris: Jean-Marie Riche, 11 Rue Condorcet, Paris (9e), France. Phone: TRUdaine, 15-39, Cable address: NEWS AIR PARIS.

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JANUARY

Fifth Annual Radar Symposium (classified), Rackham Bldg., University of Michigan, Ann Arbor, Jan. 27-29.

Society of Plastics Engineers, 15th Annual Technical Conference, Hotel Commodore, New York, Jan. 27-30.

Armour Research Foundation, Fifth Annual Midwest Welding Conference, Illinois Institute of Technology, Chicago, Jan. 28-29.

Columbia University and Sylvania-Corning Nuclear Corporation, First International Symposium on Nuclear Fuel Elements, Columbia University, New York, Jan. 28-29.

FEBRUARY

14th Annual Technical and Management Conference, Reinforced Plastics Div., Society of the Plastics Industry, Inc., Edgewater Beach Hotel, Chicago, Feb. 3-5.

IRE, AIEE 1959 Solid State Circuits Conference, University of Pennsylvania, Philadelphia, Feb. 12-13.

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NEW PRODUCT BRIEFS

SURE SCANNER. Longer on-stream ation with a minimum of mainte- e is reported in a SP-101B Pressure er manufactured by Datex Corpora- SP-101B models reportedly have ated continuously under test at 30 for over 1,000,000 revolutions (12,- 00 pressure points) before requir- maintenance. The scanner provides ures many pressures using only one ducer. The SP-101B has a low in- l volume, with a negligible effect e pneumatic response time of con- onal pressure systems. It can be ex- lly programmed to switch pressures y sequence desired, or it can be ated by means of a manual switch elect pressures to be measured. dimensions of the SP-101B are x 5⅛" x 5½". It is designed with " 24NF-3 thread pressure connec- . Caps for flush diaphragm trans- rs are available.

No. 250 on Subscriber Service Card.

EL MOUNT TRIMPOT. A lead- -actuated potentiometer that com- the convenience of panel mount- with high temperature and humidity F characteristics has been an- ced by Bourns Laboratories, Inc. ghing about 0.3 ounces and meas- .23" x 1.32" x 24", it can be ted through a 0.2" hole. The ded adapter extends through the l hole and is secured by a hex nut. ned for military applications re- ng high reliability plus sub-mini- size, model 223 reportedly meets equirements of MIL-STD-202A in- ng the 10-day humidity of method and vibration of method 204.

No. 251 on Subscriber Service Card.

ELEROMETER. A transistorized in- ting accelerometer has been mar- l by Donner Scientific Company. city contacts can be closed at ds from a few feet per second to 0 feet per second up to accuracies 25 percent over extended opera- l periods, the company said. Pres- range is 0 to 35 pounds per square absolute, temperature range 30F 59F. The unit will operate under g of vibration through 2000 cps. leration ranges from ±1g to ±20g greater are available. The acceler- er will stand short shock pulses of and long pulses of 50g. Weighing t 4 pounds, actual physical dimen- are dependent on specific range.

No. 252 on Subscriber Service Card.

GEAR CHECKER. A gear checker, model 1218A—with an integrated optical system for checking of gear leads—is available from Michigan Tool Company. It reportedly eliminates gage blocks, multiple settings, micrometers, verniers and gear trains from the setup procedure.

Circle No. 253 on Subscriber Service Card.

SECONDARY VOLTAGE STANDARD. Julie Research Laboratories, Inc. has marketed two secondary-standard reference power supplies, which reportedly provide 50 to 100 times higher voltage levels than standard cells, at a current capacity permitting direct loading by practical circuits, and at accuracies at least equivalent to an unsaturated standard cell. Model PVS-105A has a dual output of plus and minus 50 volts, or 100 volts if used end-to-end.

Circle No. 254 on Subscriber Service Card.

IN-LINE RELIEF VALVE. A valve designed primarily for high pressure, high flow, and high temperature applications, has been marketed by Republic Manufacturing Co. It is made in pressure ranges up to 5000 psi. Adjustments over entire range can be made by turning the external adjusting nuts, without disconnecting either pressure or return line. It provides free flow in reverse direction, and pilot operation provides for high flow capacity. Entire design contains one packing, an O-ring which is easy to replace without taking the valve out of the line.

Circle No. 255 on Subscriber Service Card.

GERMANIUM TRANSISTORS. A new series of germanium high frequency, diffused-base "mesa" transistors featuring alpha cutoff frequencies up to 750 mc and power dissipations of 750 mw has been announced by Texas Instruments Inc. The new transistors, 2N1141, 2N1142 and 2N1143, have minimum current gains of 12, 10 and 8 db at 100 mc and operate at junction temperatures up to 100°C with 750 mw power dissipation at 25°C case temperature. Because of their high frequency and power characteristics, TI expects these transistors to have wide application in UHF power oscillators and amplifiers where assured reliability and performance are of primary importance. All units exceed the reliability specifications outlined in MILT-T-19500A, the manufacturer says.

Circle No. 236 on Subscriber Service Card.

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COMPANY..............................

Product Mfg./Service Offered..............................

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MISSILE LITERATURE

PRESSURE REGULATORS. A 36-page catalog covering cylinder, manifold and station pressure regulators is available from Air Reduction Sales Co. The illustrated booklet contains flow and pressure specifications and inlet and outlet connection dimensions for each regulator. Adapters, station valves, flowmeters, hose connections and pressure gauges are described.

Circle No. 201 on Subscriber Service Card.

HIGH PURITY TANTALUM. A new four-page technical folder describing the application of high-purity tantalum to the electronic, nuclear, chemical and missile industries is now available from National Research Corp. It describes the various forms in which the new product is available, including powder for electronic uses, vacuum melting stock, arc-cast ingot for conversion, and tubing sheet, wire, foil and other mill products. Tables give exact chemical analysis (impurities in parts per million) and mechanical and physical properties of the products, which are of a purity previously unavailable in commercial quantities.

Circle No. 202 on Subscriber Service Card.

BROCHURE. The Fenn Corp. has released a brochure describing their facilities for production of precision aircraft components, complete helicopter rotor heads, transmissions, precision parts for gas turbine aircraft engines and jet engines, and aircraft quality gears.

Circle No. 203 on Subscriber Service Card.

POWER SUPPLIES. A new four-page two-color catalog describing solid state regulated power supplies has been released by Electronic Research Associates, Inc. These supplies combine the features of magnetic and transistor regulators and offer features not presently available in conventional designs. The catalog sheet provides full descriptive material, graphs, specifications, physical data and related information.

Circle No. 204 on Subscriber Service Card.

TEST POINT CONNECTORS. An illustrated, 6-page brochure giving specifications, outline dimensions and general information on printed circuit test point connectors is now available from the DeJur-Amsco Corp.

Circle No. 205 on Subscriber Service Card.

FIBRE RESEARCH. Two literature lists on fibre research, one on electron microscope work and the other on X-ray diffraction investigations, are available from the Instruments Division, Philips Electronics, Inc. The tabulation of electron microscope papers includes 79 articles which appeared in domestic and foreign publications. Six textbooks and reference books also are listed. A total of 58 articles are tabulated in the X-ray diffraction list. Both bibliographies list name of publication, volume number, page number

Circle No. 207 on Subscriber Service Card.

DIGITAL SYSTEMS. A catalog on tl
complete digital systems line, as w
as a two-page flyer on the digital vo
meter, has been published by Cub
Corp. The four-page catalog lists pro
uct features, brief specifications ar
ordering information on the cubic vo
meter, control unit, pre-amplifier, ac/
converter, ohmeter, scanners, print
control units and radiometer.

Circle No. 212 on Subscriber Service Car

ELECTRONIC INSTRUMENTS. The Bri
tol Co. has released a bulletin givir
specifications of its potentiometer ar
bridge instruments in indicating, recor
ing, and controlling models. Informati
on new rack mounting instruments, hig
speed and multi-point instruments, a
miniature instruments is also include
along with descriptions of standa
round-chart and strip-chart instrumen
One section of the bulletin is devot
to sensing elements and attachments f
use with Bristol Dynamaster instrumen
Resistance bulbs, magnetos, photocel
conductivity cells, frequency converte
computing, totalizing, and digital rea
out attachments are among those liste

Circle No. 213 on Subscriber Service Car

CERAMIC DISC CAPACITORS. A ne
six-page folder describing ceramic di
capacitors has been published by
Menco Co. It includes complete spe
fications data, charts and graphs on t
performance capabilities of the follo
ing capacitors: TX-Temperature Stabl
designed for applications where a mi
mum capacitance change with temper
ture is required; SS-Semi-Stable-gener
purpose with stability; GP-general pu
pose units for bypassing, coupling
filtering applications often referred
as the "space-saving" capacitors sin
they provide very high capacity in r
lations to size; TC-Temperature Co
pensating-for resonant circuit applic
tions where stability of capacitan
characteristics is essential.

Circle No. 214 on Subscriber Service Car

TRANSFORMERS. A new 24-page cat
log on pulse transformers, designed
assist engineers in applying transforme
to their specific needs has been pu
lished by PCA Electronics Inc. It i
cludes a brief history of low-level pul
transformers, their measurements, spe
fications, applications, interchang
ability, dielectric ratings, manufacturin
and other data. Also included is inf
mation on some of PCA's 2000 stan
ard design transformers, as well as ca
types and specifications data.

Circle No. 210 on Subscriber Service Ca

TRANSISTOR DIGITAL SUBSYSTEM
An 8-page facilities brochure has be
published by Tempo Instrument Inc. co
taining information on their produc
facilities and personnel in the field
transistor digital subsystems. It descrit
the transistorized "logic elements"
veloped and applied by Tempo.

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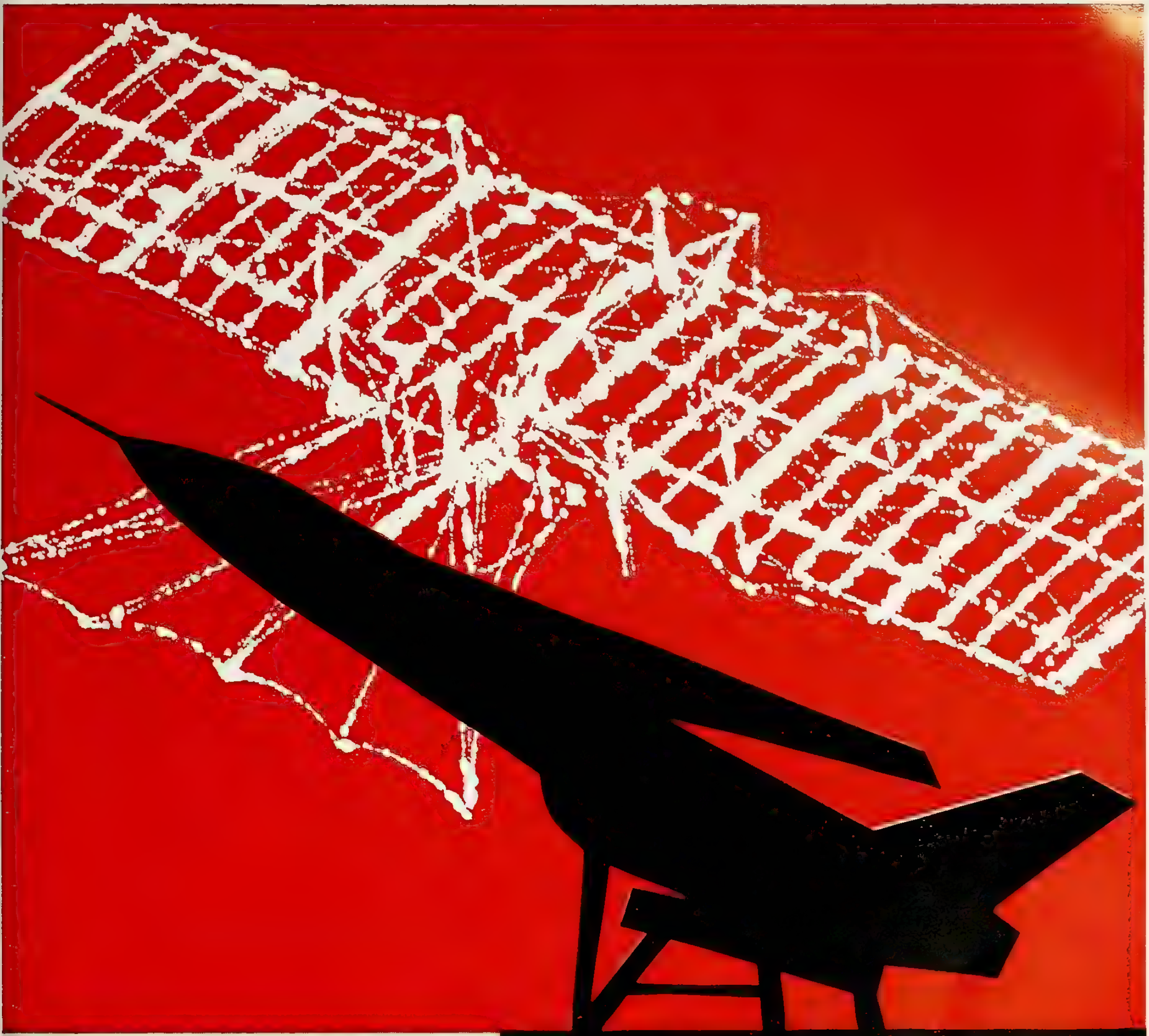

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Grove Regulators... As revolutionary in design and engineering as the technological transition from flying machine to space vehicle...Achieved a quarter of a century ago, the only regulators which could be used in the early space labs of Annapolis...still today the standard for the critical control of high pressure fluids ...Now on the threshold of space, Grove is uniquely prepared—through advance research and development —to meet the challenge of even higher pressures ahead.

GROVE POWREACTOR DOME REGULATOR MODEL GH-408—50-6000 PSI INLET...5-3000 PSI REDUCED PRESSURE

GROVE VALVE and REGULATOR COMPANY

6529 Hollis St., Oakland 8, California • 2559 W. Olympic Blvd., Los Angeles 6, California

Offices in other principal cities

Circle No. 5 on Subscriber Service Card.

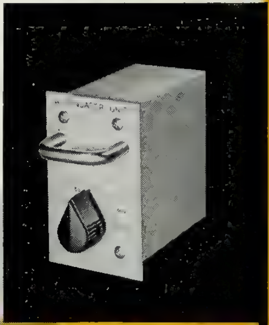
New Electro Instruments A-12 DC amplifier totally transistorized

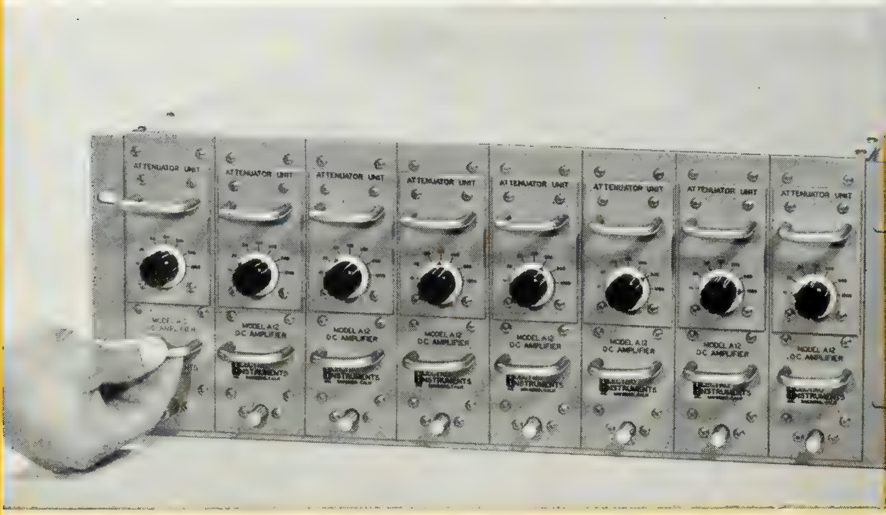
equal to or better than the best vacuum tube instruments!

The new Model A-12 DC Amplifier is the preferred systems link for amplification, normalization and impedence transformation. Use of solid state elements assures maximum reliability; power dissipation is only seven watts. Mil-type components are mounted on coated plug-in printed circuit boards for protection against vibration and corrosion.

versatility plus economy

Electro Instruments produces a series of plug-in mode selectors and attenuators for the A-12: single ended, differential and operational, fixed and variable gain.





Eight to a rack
The A-12 is packaged for high density use; mounts eight across in 19" relay rack panels.

SPECIFICATION SUMMARY

	Single Ended Input
Gain:	Fixed gain set to any value from 10 to 1000 inclusive by front panel plug-in units. Gain switching plug-in attenuator available with gains of 0, 10, 20, 50, 100, 200, 500 and 1,000. Adjustable upward 6db from setting with potentiometer.
Input Impedance:	100 megohms shunted by 0.001 mfd (typical).
Source Impedance:	5K or less (to meet noise specification).
Drift:	Less than 2 microvolts in 200 hours at constant ambient temperature. Less than 0.4 microvolt per degree centigrade.
Ambient Temperature:	0° to 50°C.
Noise (Referred to input):	0-3 cps 5 microvolts peak to peak 0-750 cps 4 microvolts rms. 0-50 kc 8 microvolts rms.
Frequency Response:	±3db to 50 kc (typical); ±1.0% to 2 kc
Output Capability:	±10 volts at ±100 ma DC or peak AC to 10 kc

Circle No. 6 on Subscriber Service Card.

Write today for complete specifications on single-ended, differential and operational models.

Electro Instruments, Inc.
3540 Aero Court
San Diego 11, California

FEBRUARY 2, 1959

AX-1 POLARIS LAUNCH

missiles and rockets

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AN AMERICAN AVIATION PUBLICATION

4

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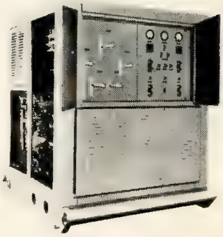
FOR LEACH/INET

NEXT TIME...LOOK TO LEACH/INET FOR PRECISE GROUND POWER

This INET 400-cycle ground power unit was tailor-made for the Atlas. The unit operates in parallel with the missile's power system and provides remote control regulation. Frequency regulation is ±0.2%. With shock load equal to a third of rated output, frequency recovers to ±0.2% in 0.15 seconds. Voltage regulation is ±0.5% with recovery time at 0.30 seconds.



LOOK TO LEACH INET DIVISION
LEACH CORPORATION

18435 SUSANA ROAD, COMPTON, CALIFORNIA

DISTRICT OFFICES AND FIELD REPRESENTATIVES IN PRINCIPAL CITIES OF U.S. AND CANADA • EXPORT: LEACH CORPORATION, INTERNATIONAL DIVISION

CLAY PIGEONS

low-cost, supersonic target drones

Clay pigeons that fly faster than sound—that's a nutshell description of the new low-cost target drones developed by Bendix Systems Division.

Program-controlled (with radio override, if desired) they will provide the answer to our need for airborne target drones which can be built in quantity and at a moderate cost. They are ideal vehicles for testing the effectiveness of our new aerial weapon systems, as well as the skill and training of the men who fly or launch them.

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missiles and rockets

MAGAZINE OF WORLD ASTRONAUTICS

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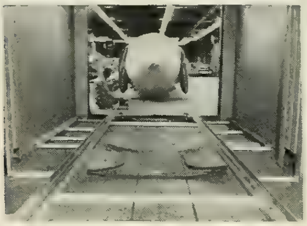
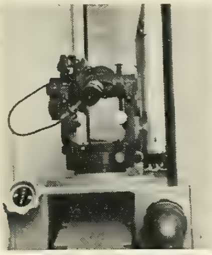
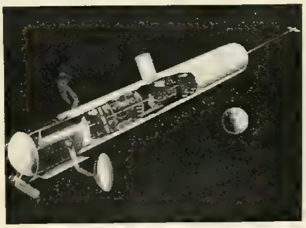


Now it's rail transportation for large missiles as NYC tests transport feasibility. (p. 19)

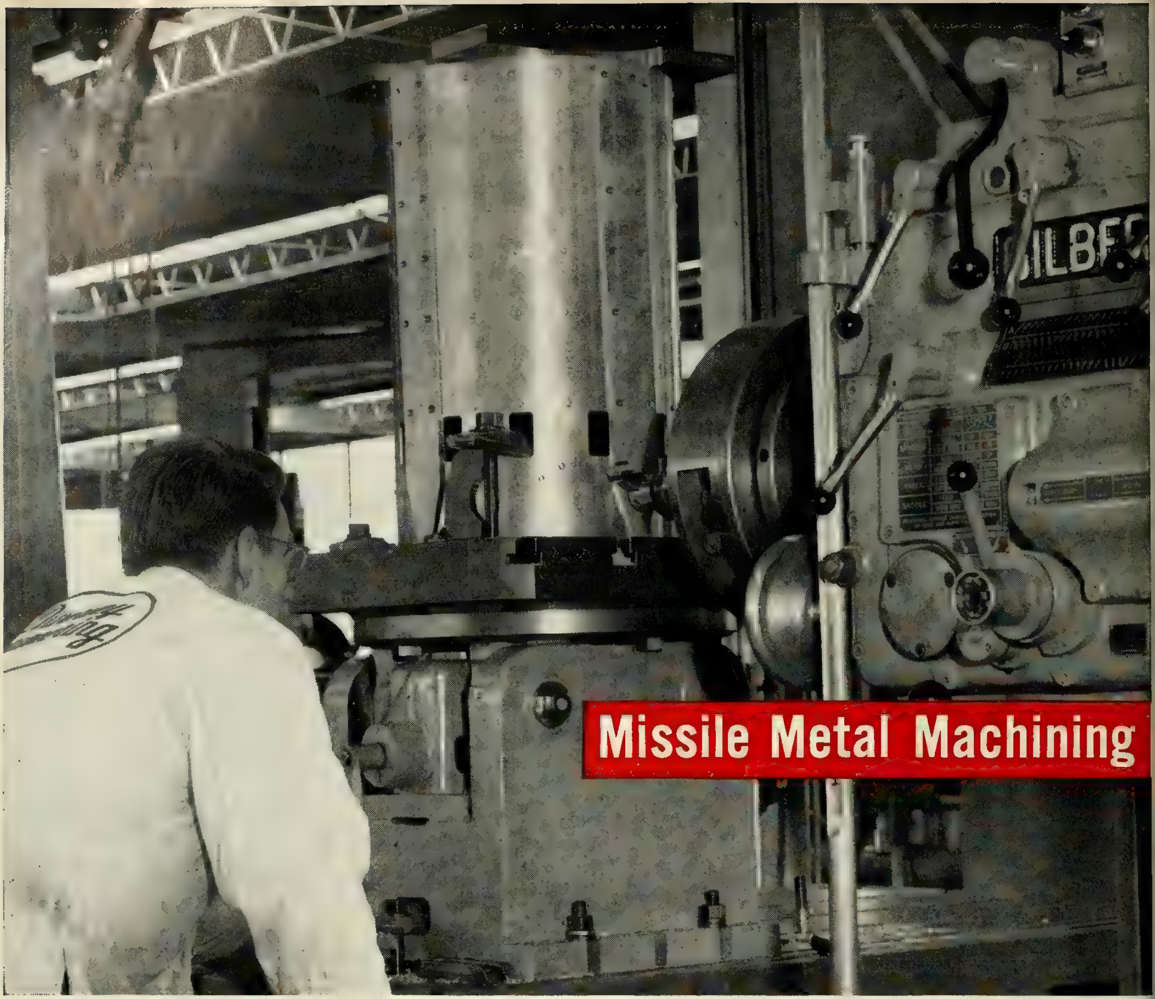


Perkin-Elmer has developed new azimuth alignment theodolite for *Jupiter*. (p. 30)



Orbiting scientific laboratory like this Rocketdyne conception is goal of U.S. astronautics research. (p. 12)

Army's tracking ship may have long-range radar for anti-missile detection. (p. 32)



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In My Opinion . . .

. . . it has become clear in the last couple of years that the Army's chances of staying in the space business are diminishing constantly simply because of poor public relations and lack of guts on behalf of the Army's top planners.

To be sure, almost every man and woman in this country is familiar with the Army's missile and space capabilities. But the Army's failure to push ahead for tomorrow's ventures and challenges is known to but few.

The reason for the inadequacy starts at the top, where Army leaders have been less than forceful in selling the service's achievements, capabilities and needs. Too often the selling—at least in public—has been left to Maj. Gen. John B. Medaris and Dr. Wernher von Braun, at times when they could ill afford to be away from their missile business in Huntsville.

A few weeks ago we asked Dr. von Braun how the Army's manned ballistic rocket carrier program was coming along, and he said: "Well, right now I think the Army has difficulties establishing a requirement for the program."

Why is it so difficult for the Army to establish requirements? We refuse to believe that the many excellent Army leaders have any difficulties recognizing requirements—if this is what it takes.

Let us keep in mind that the Russians have said they are aiming to establish bases on the moon. Also, remember what Brig. Gen. Homer Boushey, AF research chief, has said about the moon: The moon is high ground—the nation that controls the moon will control the earth. Perhaps, this may be somewhat of an over-enthusiastic statement. But—indeed, it doesn't take much to figure out how the moon can be used to house observation posts, communications centers, reconnaissance stations and even automatic launching sites.

If there is the slightest possibility that this is what the Russians might do—then we must beat them to it. This—furthermore—would be a logical job for the Army. No other service has a Corps of Engineers capable of building the moon sites and of managing the construction of parts and components on earth before they are ferried to the moon. No other service has a Signal Corps capable of handling the complex task of setting up all the communications and tracking gear required. No other service has the capability to produce the rocket hardware that is currently manufactured by industry and the Army at Huntsville—to successfully complete this nation's effort to establish a base on the moon for military reasons.

Yet, we know of no Army effort along these lines. In fact, we've just learned that ARDC's Wright Field already has invited industry to bid on recoverable lunar capsules and vehicles—designed for landing on the moon and take-off for return to earth, the first step in establishing manned lunar operations. Obviously, the Air Force is looking ahead in its planning—which is what they must and should do. We wonder if the Air Force is hamstrung because of lack of requirements . . .

We recall the days when Army Secretary Brucker was known as a fighter, and as a man devoted to the advancement of military sciences, to the Army, and to its requirements. This country certainly needs the Army's missile capabilities, Mr. Brucker. It is up to you to push for the requirements that it will take to keep the Army in the business. And don't forget it will take as much public and government relations as that produced by the Air Force at all times.

Erik Bergaust

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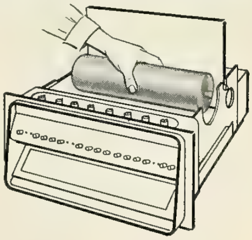

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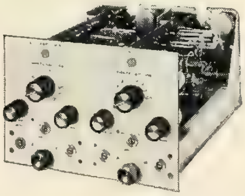

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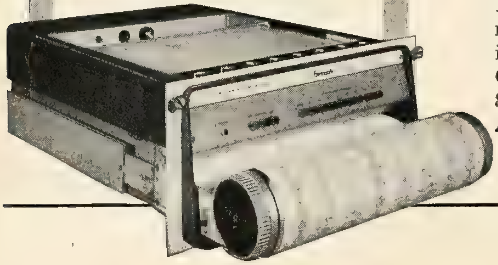

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washington countdown

"Busiest" People in Washington . . . today are the Pentagon's legislative liaison personnel, who number 302. Army has 71; Navy, 70; Air Force, 147; and DOD, 14.

The man in NASA's space capsule . . . will be an AF officer on active duty who has graduated from one of the two AF test pilot schools. He will be screened out of 110 candidates who have these requirements and also are college graduates with degrees in the physical sciences or engineering. He will be younger than 40, physically and mentally adaptable to space flight, and will have 1500 hours of flight time.

Bombers and *Minuteman* . . . are what AF Chief of Staff Gen. Thomas White believes to be the best war deterrents. He told the Armed Services Committee that aircraft in the air plus *Minuteman* at widely dispersed bases would provide a strong deterrent force.

One explanation . . . of Khrushchev's boast of "serial production" of ICBM's is that the Russians have so much confidence in their long-range weapon that they have "frozen" its design.

One hit, one "solar orbit" miss . . . seems to be the world lunar program for Feb. 27-28. The Army plans to fire its 13-pound payload past the moon into solar orbit, while the Soviets seem ready to try to impact a multi-thousand-pound payload on the moon.

Army has abolished . . . position of Assistant Secretary for Civil and Military Affairs, giving its responsibilities to Assistant Secretary Dewey Short (Manpower, Personnel and Reserve Forces).

McElroy's statements . . . to the press have done little to clear up the future of several missiles. He said the *Jupiter-Thor* controversy could go either way, depending on requests from overseas allies. Final number of overseas squadrons probably will be eight. He said the status of *Nike-Zeus* is not certain. "We haven't got *Zeus* and we don't know when we will get it," he said. McElroy did clear up one area—the overall air defense program will be under NORAD. Army would control close-in defense with *Nikes*. McElroy said policy on excess funds voted by Congress is to hold off spending as long as possible in view of possible urgent use late in year, and buying of military hardware may be cut through better advanced planning, heightened capability and improved use of equipment.

12 *Polaris* submarines . . . will be completed or on the ways by 1961, McElroy told the House Appropriations Defense Subcommittee. He said that in addition to the nine FBM subs already provided for, money would be sought for three more.

The number of missiles . . . aboard the Fleet Ballistic Missile submarine never has been officially announced, but 16 *Polaris* IRBM's is conceded as a sound estimate. The Navy discounts reports that later submarines will be large enough to carry 50 missiles.

Puzzled Congressmen . . . were told at a recent intelligence briefing that the Defense Department assumes that the Russians do not have an ICBM because they have not fired one recently. "We think that they are having trouble," Congressmen were told. "Couldn't it be," asked one less-than-satisfied Congressman, "that they are through testing and now in production?"

The Stans memorandum . . . which forbids witnesses appearing before congressional committees from asking for additional funds or disagreeing with the budget as outlined by the Administration is doing little to keep the word from getting across. Major witnesses thus far have followed the order and said in so many words they were not asking for more money—and then proceeded to say that certain programs are not strong enough.

High-altitude missile . . . launching sites seem improbable in the U.S., according to DOD spokesmen. While they would increase ICBM range, logistical problems probably would cancel out their advantage.

U.S. will show off . . . some space hardware in Moscow at the American National Exhibition beginning July 4. It is being planned jointly by the State and Commerce Departments and USIA.

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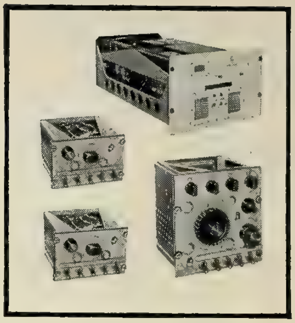

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industry countdown

Detection system for *Subroc* . . .

may be *Julie* or *Jezebel* under development by Daystrom and Bell Labs. Both systems which fire small explosive charges from AS aircraft or submarine torpedo tubes reportedly are in advanced state of development and wanted by Navy. They can even detect submarines concealed by density layers.

Republic scientists . . .

have evolved a new mathematical method for determining lunar and interplanetary trajectories which reportedly is accurate to .0002%.

Contracts totalling $110 million . . .

have been received by GE for *Atlas* missile guidance systems. Total contractual agreements in the GE program now total about $193 million.

Indian Head Propellant Plant . . .

is producing some of the ingredients used by Allegheny Ballistics Lab. in its development work for a double base propellant for possible use on *Polaris*. Planning is underway for modification of facilities for pilot line production, and an architectural and engineering contract award is expected soon.

Defensive network of *Bomarcs* . . .

is apparently still many months away, as evidenced by Lear, Inc.'s Astrionics Division backlog of 124 data link receivers scheduled for delivery by August. The receivers are an important part of the *Bomarc's* guidance system. A *Bomarc* base requires either 56 or 112 of the area defense missiles for optimum capabilities.

Rocketdyne has shifted . . .

1200 people from five separate facilities in a move to consolidate activities. Most personnel from the service division will move from the San Fernando Valley facilities to the former site of Atomics International in Van Nuys. Rocketdyne conducted 4085 rocket engine tests at its field laboratory during 1958, using an average of 315 tons of liquid oxygen per day.

Better than 90% reliability . . .

is being obtained with the *Bullpup* air-to-surface missile, a Navy spokesman says. While early evaluation versions of the missile turned in a performance approaching 100%, first production-line missiles were only about 20% effective, the spokesman said. However, this was rapidly rectified by prime contractor Martin-Orlando. This will allow development to operational forces this spring.

Four companies share . . .

in the design and construction of the first two *Titan* bases being built at Vandenberg AFB and Lowry AFB near Denver. Costing $50 million each, the ICBM facilities will be built by: Daniel, Mann, Johnson & Mendenhall of Los Angeles; Rust Engineering Co. of Pittsburgh; Leo A. Daley Co. of Omaha and Mason, & Hangar-Silas Mason Co. of New York. Plans call for launching facilities to be built later at Omaha, Spokane, Topeka and Cheyenne.

$31.4 million for *Terrier* III . . .

has gone to Convair Division of General Dynamics. The advanced version of the surface-to-air missile will incorporate improved guidance and will top the 20-mile range of the present *Terrier*. The all-weather air defense weapon will be used on ships formerly scheduled for *Terrier* II.

Budget-bypassed *Regulus* II . . .

within 30 days will begin new duties as a target drone at PMR. *Regulus* II is also being eyed as a possible target at Canaveral for *Bomarc*, and a NATO weapon.

To clear up the situation . . .

regarding Thompson Ramo Wooldridge Inc., the Air Force has issued the following statement: "Space Technology Laboratories Inc. and TRW may now bid on contracts for which STL has systems engineering and technical direction responsibility without the approval of the Assistant Secretary of Air Force for Materiel." This applies generally, AF said, to prime and first tier sub-contracts but leaves the door open in case there should be an imperative reason for TRW bidding on even an STL-involved project. Inversely, of course, TRW may bid on any contract in which STL is not involved.

U.S. Research Aims at Space Lab

by Clarke Newlon

WASHINGTON—A representative of the science-management group heading the nation's missile and space exploration activities—a man who prefers not to be identified—has told m/r that the present goal of all major U.S. astronautics research is the establishment of a manned scientific laboratory in orbit about the earth or upon the moon.

This has yet to be announced publicly, but the fact that it is being planned is an answer to many critics of U.S. astronautics progress who believe the country must start with a well-defined objective in space exploration.

It is conceivable, the source told m/r, that such a project could be assigned to the military services as a defense requirement, a category for which Congress is inclined to allocate more money. He said such a base might serve as both a science laboratory and a military installation.

His own preference is for setting up the laboratory on a space platform 300 to 500 miles above the earth. He said this would be a good location because it would be easy to contact and resupply and because it would be between the earth and the first Van Allen radiation belt. Other scientists favor the moon, he conceded, because it provides a ready-made solid base already in orbit.

- **Billion-dollar project**—Such a laboratory would cost at least $1 billion, he estimated, considerably above the combined space budgets of government space agencies at the present, although the cost probably would be spread out over more than one year.

While the science laboratory would be only a stepping stone into future space exploration, it does provide a goal toward which the present varied and sometimes confusing U.S. space projects can be pointed.

"We have at present," the source said, "several projects to put a man in space. There isn't much doubt we can do this. But after we get him there—and bring him back—what then? Generally, I believe, you will find that both the civilian scientists and the military leaders agree that the greatest achievement we could make at this time would be to get a space lab established from which we could learn enough to proceed further."

- **New theory urged**—Said another scientist:

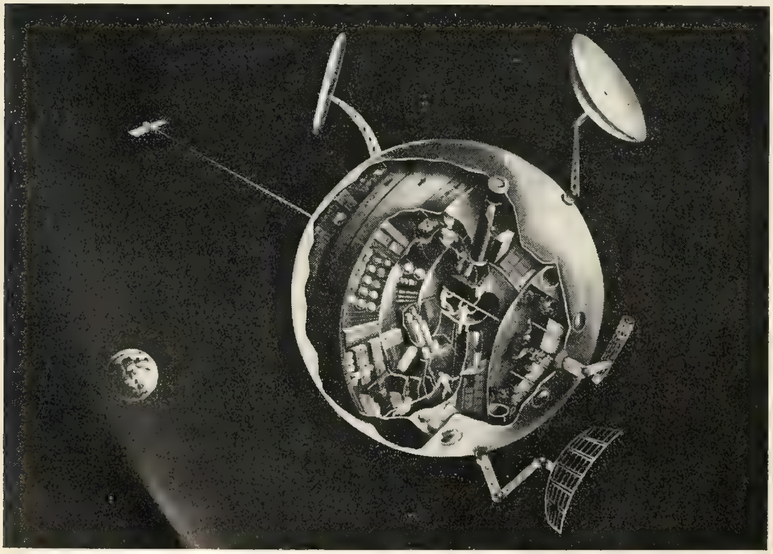
"In the field of physics, a new comprehensive theory encompassing electromagnetic phenomena, gravitational phenomena and the nature of fundamental particles and nuclear forces is urgently needed.

"At present we have Maxwell's equations for electromagnetic phenomena, (and also the Einstein/Planck equations for photo-electric effect), Einstein's equation for gravitational phenomena, the quantum theory (quantum mechanics, wave equations) for behavior at the microscopic or nuclear level.

"One comprehensive theory and set of equations tying all of these phenomena together would constitute a breakthrough in theoretical physics probably of greater importance than any other achievement in the entire history of the science."

Since many of the laboratory observations needed to provide important input data for derivation of such a theory might be better acquired from a space platform in orbit or from a lunar base than from the surface of the earth, he added, early establishment of a space platform or lunar base becomes the first major space-age objective.

Such a space laboratory would



ONE CONCEPT of the space laboratory is this by Rocketdyne, weighing 250,000 pounds. As pictured with a crew of 50, it would need about 15 million pounds of thrust to be placed in orbit, and undoubtedly would be put up piecemeal. The sphere, about 60 feet in diameter, could orbit at low altitude (300 to 500 miles) or as high as 22,500 miles.

provide almost unlimited possibilities for studies in the astro-medical, astrophysics and astronautical fields. Once through the atmosphere a relatively unimpressive telescope will reveal more than the greatest observatory on earth.

As another example of information to be gained, scientists pointed out that observation of the distribution of matter in the universe would enable them to determine curvature of the space-time continuum and arrive at a better theory of the origin of the universe. Still another subject for study, they noted, is the origin and nature of primary cosmic rays or particles.

• **A base camp**—Dr. I. M. Levitt, director of the Fels Planetarium, Franklin Institute, inclines toward believing that the scientific space platform will come first and provide a stepping stone toward similar locations on the moon—and other planets—even to eventually colonizing them. He points out that transporting supplies of any kind to the moon would be tremendously expensive. Because every pound so transported requires several pounds of fuel and hardware for the trip, he says, extensive loads cannot be carried until propulsion is greatly improved.

• **Likely powerplants**—Although a final decision is far off, it is probable that the million and a half-pound-thrust clustered Rocketdyne engine project at the Huntsville ABMA may be used eventually for such a project. Another possibility is the million-pound-thrust single-chamber engine for which NASA has just awarded a $102-million development contract to Rocketdyne.

While the single-chamber engine could be clustered also, to provide a tremendous thrust, its development is expected to take from four to six years, while the ARPA-sponsored project at ABMA has a time table of from 12 to 18 months.

Under present plans, ABMA will cluster about eight of the 160,000-pound-thrust engines to produce a giant capable of lifting a 3000-pound payload to an ultimate speed of 22,000 mph. At least one additional stage would, of course, be required to place the payload in orbit.

ABMA will build the entire booster around the clustered engine with its own in-house capability at Huntsville. The Army's Dr. Wernher von Braun, who is in charge of the cluster enterprise, is himself an advocate of the space laboratory.

Another early concept of the space science laboratory visualized it as a 24-hour satellite, that is, one designed to orbit once each 24 hours with the earth, thus remaining over the same spot on our planet.

Congress . . .

Hassle Over Size of Red Lead

by Erica Cromley

WASHINGTON—The scramble to investigate the nation's space-defense posture has begun on Capitol Hill with a gloomy-rosy tug of war between Administration officials and Congressional critics. Defense Secretary Neil McElroy's "no positive evidence" statement regarding Russia's lead on operational ICBM's moved Sen. Stuart Symington (D-Mo.) to charge that the United States will trail Russia in long-range military missiles by four to one in 1961.

The controversy is getting top priority on Democrat-controlled Capitol Hill with at least five House and Senate committees investigating the nation's defense and space programs.

The House Committee on Science and Astronautics' inquiry is slated to start in mid-February and continue off and on throughout the Congressional session.

The emphasis reportedly will be less on laying blame than on boosting the rate of progress.

Most spectacular of the Congressional Space probes will undoubtedly be the Senate Space Committee hearings, in conjunction with the Defense Preparedness Committee. Senate Democratic Leader Lyndon Johnson heads both groups.

Johnson said the hearings will seek to determine if the United States is doing everything it reasonably can in the exploration of outer space and in defense against military aggression.

The House Government Operations Military Subcommittee is planning an inquiry into the management of the U.S. missile program.

The Senate Armed Services Committee is studying the Nation's general defense posture, while its Subcommittee on Central Intelligence is making an appraisal of Soviet missile progress.

• **Other investigations**—Other upcoming Congressional probes include investigation of the weapon system concept coupled with a study of military procurement policies generally. Conducted by the Hebert Investigations Subcommittee of the House Armed Services Committee, the hearings will look into "loopholes in the law" which limit competitive bidding.

• **Procurement bill**—Meanwhile, a bill to streamline military procurement practices was introduced by Sen. Leverett Saltonstall (R-Mass.). The ranking Republican member of the Armed Services Committee said the major purposes of his bill are to reduce lead time in new weapon development and to speed up the "decision-making process."

Other recent Congressional developments include:

—An indication that the House Appropriations Committee will get into the defense-probe act during its budget hearings with a look-see into contractors' relations with the military.

—A report on former government employes now working for the defense industry, being prepared by the Library of Congress for Rep. Edith Green (D-Ore.).

—A charge by the House Small Business Committee that the "real culprit" behind the decline of small manufacturers' role in the defense picture is the weapon system concept, which the committee says gives the major companies control of all subcontracting. The Senate Small Business Committee also called for more opportunity for smaller firms to share in research and development contracts.

Astronautics Tests

Jan. 21—First production-line *Jupiter* made fully successful 1700-mile flight from Cape Canaveral in the 14th test flight (including the *Juno II* lunar probe). Nose cone was tracked by Operation *Gaslight* team but no effort was made to recover.

Jan. 23—*Thor-Able IV* launched in unsuccessful nose cone re-entry test. Second stage, topped with sharp, tapered nose cone (reportedly a *Minuteman* test failed to ignite.

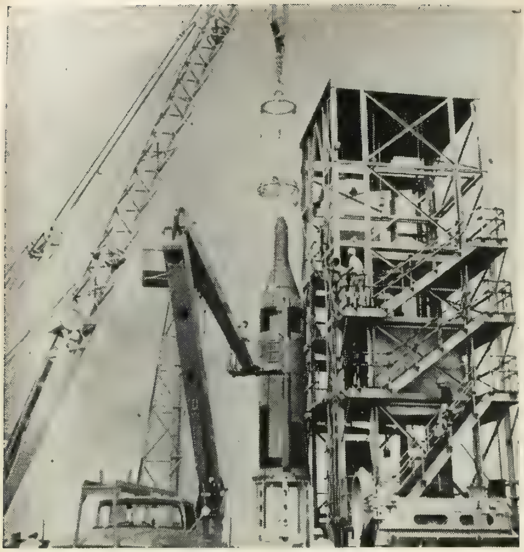
Jan. 27—Telephone-launched *Bomarc* fired from Canaveral at F-80 target. Successful.

Jan. 27—*Atlas* launched from Canaveral on what was believed to be a 4,500 mile "routine" test shot. On basis of early telemetry, test achieved most "objectives," AF said.

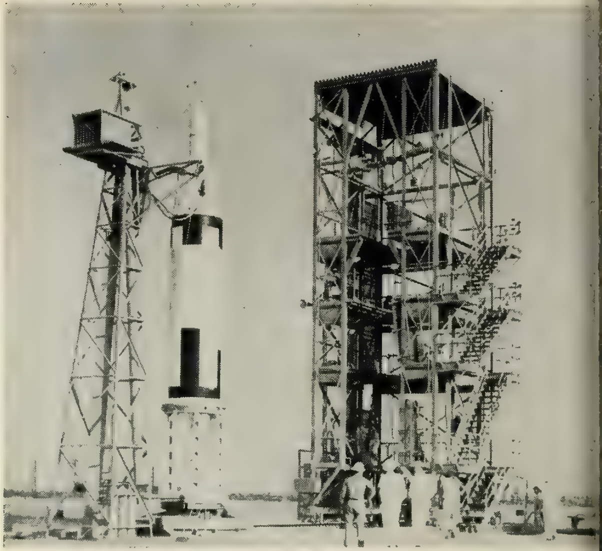
Jan. 31—*X-15* was scheduled to be carried aloft by *B-52*, but no drop was planned.

Polaris AX-4 flight of Jan. 19 reportedly failed as a result of temperature build-up from aerodynamic heating, forcing a malfunctioning of sensitive controls located on the body of the missile. Missile was range-destructed.

ASTRONAUTICS in the news . . .

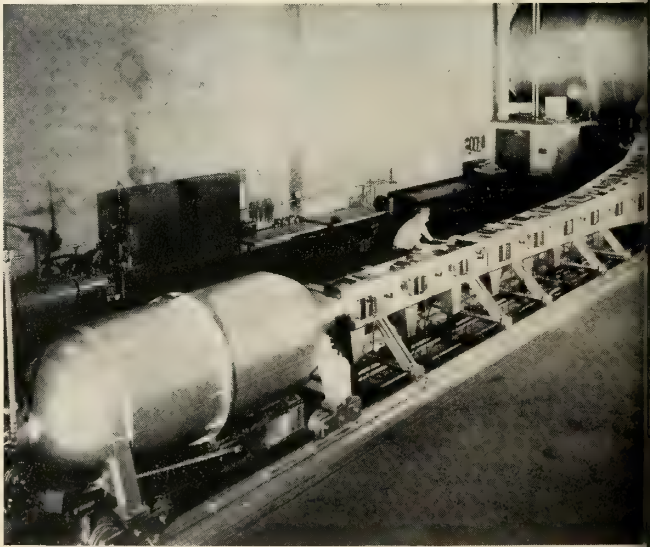


Polaris **AX-4 is positioned on launching pad at Cape Canaveral prior to its Jan. 19 firing. Missile is transported to site by a trailer erector. Crane then lifts it to top of pad.**



UMBILICAL CORD attached ready to fire, the gantry crane is moved away. The AX-4 was the 26th flight of the *Polaris* test program. Flight was reported a "partial success" after malfunction caused range destruct.

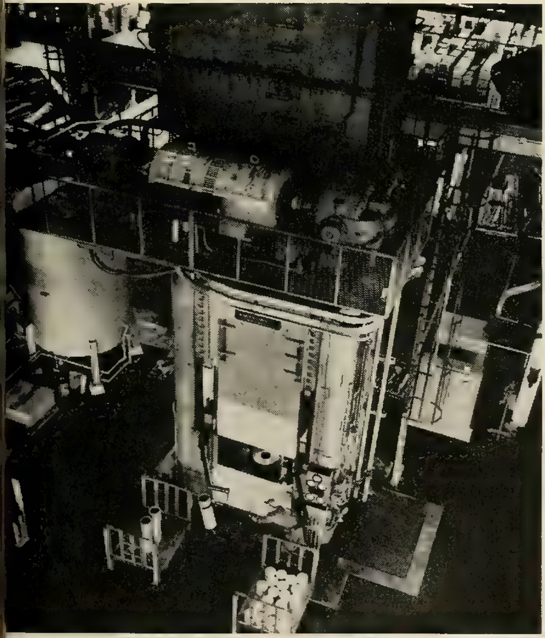
FINAL CHECKS on the *Atlas* main engine cluster are conducted by technicians at the Propulsion Field Laboratory of Rocketdyne. During 1958 Rocketdyne conducted 4,085 large engine tests.



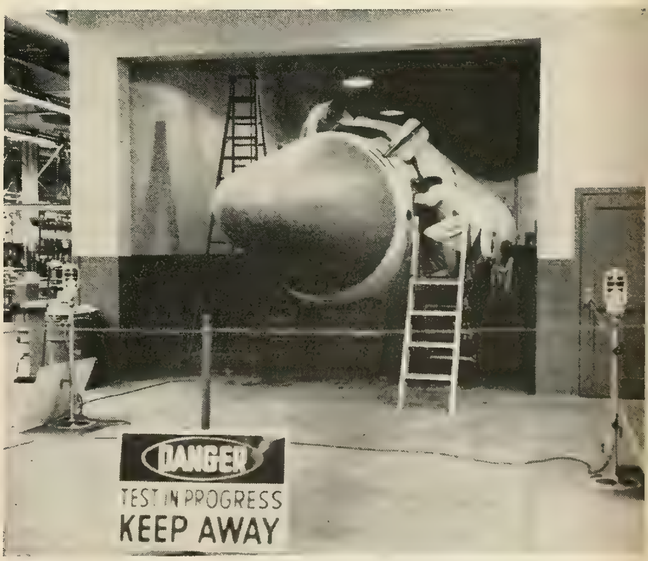
ATMOSPHERE ENTRY simulator at Ames Research Center, Moffett Field, Calif. Air flowing through the trumpet-shaped nozzle in the center gradually changes in density in the same way the earth's atmosphere changes in density with altitude.

enie, MB-1, rocket-powered air-to-air missile with uclear warhead capability is positioned under the ing on an F-89. Missile is also carried in special eapon bays of the F-101, F-102 and F-106.

"WORLD'S LARGEST" fiberglass radome designed and built by Goodyear Aircraft Corp. for the Missile Detection Systems Section of GE, measures 68 feet in diameter and stands more than seven stories high. It can be erected by six men in 80 hours.



EW 2,500-TON vertical hydraulic impact press recently stalled at the Cressona, Pa. works of Aluminum Company f America. Alcoa is now equipped to produce impacts in zes up to 12 inches in diameter and 60 inches in length.



FACTORY TEST of the *Jupiter* IRBM at the Army Michigan Ordnance Missile plant, operated by the Chrysler Corp. The plant which produces *Redstone* and *Jupiter* missiles on parallel assembly lines, has 2.1 million square feet of floor space.

STATIC TESTS OF ENGINES and other components are conducted at 4,000-acre Santa Cruz facility.

Lockheed Emphasis Is Systems Management

Perfecting ability in systems management is setting pace at Lockheed Missiles and Space Division whose sales this year will be one-third corporation's total.

by William O. Miller

SUNNYVALE, CALIF.—"The essence of making a missile is taking thousands of parts and putting them together into a reliable weapons system—and this integration is not done by component manufacturers."

L. Eugene Root, a vice-president of Lockheed Aircraft Corporation, employs this philosophy as manager of the fast-growing Lockheed Missiles and Space Division. The name was changed recently to incorporate the word "space," although the old short title "LSMD" still stands.

"Of course the component manufacturer plays a very important part, but beyond the component or article itself you have the greater problem of assembly and integration, of testing, ground handling, training and the other prerequisites to the delivery of a complete and reliable product," Root continued. "All this requires a great deal of management competence and long-range planning."

This is Lockheed's forte, the LMSD general manager said—ability in complete systems management. Ample evidence is the increase in missile and satellite development revenues from 7% last year to 31% of the company's total sales this year.

"This ability presently is dedicated to two of the nation's six D-X priority projects—the Navy's submarine-launched *Polaris* and the ARPA's satellite program *Discoverer*," Root said, adding that the two top-priority projects are the only programs physically handled at Sunnyvale. Other Lockheed missile projects including the *X-17*, the air-launched ballistic missile concept, Kingfisher drone and *X-7A* are at the Van Nuys facilities.

- **Greatest ability**—Lockheed is emphasizing systems management, Root continued from his offices in Sunnyvale.

"I know of no plans now to expand our in-house capacity to develop and produce all the components of a missile such as the guidance and electronics and propulsion units," he said. "We must, however, have a high capability in these areas and maintain large staffs of knowledgeable personnel as a prime contractor for putting together complete missile systems."

"Those who forecast a concentration of abilities in the big companies fail to reckon with the problems of starting such divisions from scratch," he continued. "On an economic and competitive basis, the capabilities of the experts on these fields—giants of American industry—must be considered."

Better than 60% of the items going into missiles at Lockheed are procured from other sources—both large and small businesses. For *Polaris*, as an example, propulsion is being supplied by Aerojet General and General Electric will produce the guidance system being developed by Massachusetts Institute of Technology.

- **Subcontracting**—As the *Polaris* system manager, LMSD supervises and coordinates the efforts of 739 subcontractors.

"One of our major tasks is to have full knowledge of capabilities and where they are," Root said. He pointed out that 80% of 20,000 work orders

NET CATCHES scale model of Navy's *Polaris* in underwater launching tests.

for the first six months of 1958 went to small business concerns. These totalled more than $30 million and represented 42% of total purchases from other companies.

The rapid expansion to almost a third of Lockheed's total sales in less than five years would have been impossible, Root says, without the ability to draw on the parent corporation and its other divisions.

• **Parent company**—Though Lockheed-built planes have been flying since 1913, and Lockheed Aircraft Company came into being in 1926, the history of today's $460-million corporation really began in 1932. In that year, in the depths of the depression, seven men including present Chairman of the Board and Chief Executive Officer Robert E. Gross and other senior officers bought their bankrupt predecessor for $40,000. That same management through 27 years has made Lockheed one of the nation's 100 largest companies and one which ranks fourth in government business—$755.1 million during the fiscal year ending last June 30.

With corporate offices in Burbank, the California Division has plants in Maywood and Palmdale; the Missiles and Space Division in Sunnyvale has installations in Van Nuys and Palo Alto; and the Georgia Division has two plants. There are four service subsidiaries in the aviation field.

• **Why LMSD?**—LSMD was an outgrowth of a group of specialists from the company's preliminary design section in the engineering department set up 10 years ago to work on guided missiles.

In 1953, it was decided to form a separate corporate entity and in the next year Lockheed Missile Systems Division was established. In March, 1954, the growing division was moved from Lockheed's main Burbank plant to a 77-acre site at Van Nuys, still site of much of the division's operations.

As the work load increased, more space and facilities were needed. In 1956 the headquarters was moved and research and development laboratories were set up at two San Francisco Bay area sites. A 26-acre site in Stanford University's industrial park was chosen for the research and development center. Administrative offices and other activities were set up on a site originally taking in 275 acres adjacent to the Navy's Moffett Field at Sunnyvale. The Sunnyvale property has been expanded until today it occupies 645 acres.

In the same year, LMSD took over 4,000 acres in the nearby Santa Cruz mountains for static testing of missile systems and their components, mainly propulsion units. Within the Santa Cruz facility are test areas for the *Polaris* and the *Discoverer* satellite, in addition to administration buildings.

Field bases are maintained at Air Force Missile Test Center, Alamagordo, N.M., Air Force Missile Test Center, Patrick AFB, and Vandenberg AFB.

• **$300 million business**—Figures for the calendar year 1958 have not yet been released, but Lockheed missile and space contracts from Air Force, Navy and Army are expected to top $300 million. In the first three quarters of the year, contract awards totaled $275 million. Missile sales reached $214 million for the first nine months of 1958, second only to sales of military planes and spares, which were $293 million, or 43% of the corporation's total sales.

More than 14,000 persons are employed by LMSD, 10,200 at the Sunnyvale facilities and the nearby Palo Alto research and development laboratories.

• **Team concept**—Backing up Root is a team of the best in the nation—scientists, technologists and, equally important—administrators. H. J. Brown and Willis M. Hawkins, assistant general managers, are Root's right hand men.

"We've invested heavily in our people," said Hawkins. "In this way we have been able to acquire quickly the talent in depth required for work in the missile and space field."

Hawkins estimated that there is a 30% greater talent span in missile work than in aircraft, but went on to say that the same increased talent depth would be required as aircraft get more complex.

"The missiles system management concept is under attack from a number of directions," Hawkins said, "but we believe that it is the only way to do what we must."

"There are several reasons this is true—to permit utilization of all the knowledge and capabilities we have in the nation, to permit competition, and to be able to evaluate where you are going."

Hawkins said small business is highly expert on certain small elements. Under the missiles system management concept they can be fully utilized.

"One of the big problems," Hawkins said, "is finding a way to evaluate what you are doing, and where you want to be when. After this, 75% of the monitoring will be done by your customer, the government."

As explained by Stanley W. Burris, manager of the XN Weapon System, which is the Lockheed designation for *Polaris:*

"We are concerned with the 'erosion of the project year'—how much are we getting in useful return for what we are doing—and to determine this we have gone to outside sources. This includes operations analysis, cost fac-

L. EUGENE ROOT (right) discusses *X-17* with Stanley W. Burris, manager of the Lockheed team working on *Polaris*.

LOCKHEED TECHNICIAN checks nose cone in spark-heated tunnel at the Palo Alto Scientific Research Laboratory.

tors, and working to rule out obsolescence at maturity."

Balance of effort, Burris said, is most important. He pointed out that there are three areas to be considered: the missile or flying elements, the nonflying or support elements, and the system synthesis and operational crew elements.

"Operational countdown time is the only real measure we have for measuring progress on the degree of balance obtaining at any point in time," Burris explained. "Through this balanced effort, we obviate traditional practice which heretofore has pushed development of flying hardware before nonflying hardware, resulting in too late a start on support hardware, and delinquent starting of operational requirements studies."

- **Other LMSD projects**—In addition to the two DX priority projects—*Polaris* and the military satellite program—major projects underway include:

X-17—completed as a project eight or nine months ago. Though contract has been completed, this solid-propellant vehicle which successfully flew 92% of all its launches in the Air Force launches and 100% in early *Polaris* program studies, is believed to have continuing value as a research tool. It has played a major role in solving re-entry problems.

X-7A—volume production this year has been the same as last on this recoverable ramjet test vehicle. The Air Force recently awarded a contract of some $8 million for continued flights testing engines and components of other missiles. Lockheed believes it has many possibilities as a research tool.

Q-5—target drone in the supersonic speed range evolved from the *X-7*. *Q-5* incorporates a Firing Error Indicator which registers theoretical hits and angle of pass, and a Target Area Augmentation device which permits modification of radar pattern to simulate plane or missile larger than itself.

WS-117L—A $7-million building is being built adjacent to main offices at Sunnyvale to house personnel working on the *Discoverer* satellite. First launchings of the *Discoverer* satellites are to be carried out at Vandenberg AFB.

ALBM—Lockheed built the missile recently launched from a B-58, and is presumed to be one of the three contractors working on the air-launched ballistic missile system.

Space vehicle projects—Lockheed has proposed satellite laboratory which could be operational within 10 years (m/r Jan. 19, p. 19).

Human engineering—In conjunction with its space vehicle programs in which Lockheed is implementing the complete systems approach, broad studies are underway in the field of human engineering and crew fatigue.

X-17 **WAS FIRST ballistic missile to prove nose cone could survive re-entry of Earth atmosphere.**

- **Polaris**—Under the Navy's Special Projects Office headed by Rear Adm. W. F. Raborn, Lockheed is the prime contractor and missile system manager.

"Lockheed has fitted into role of missile system manager in a very fine, efficient and successful manner," Admiral Raborn says, "They make a fine partner and that is just what we consider them—the Lockheed people are doing an outstanding job."

The *Polaris* or XN personnel are housed in the Naval Industrial Reserve Ordnance Plant. This building, built for the Navy on land at Sunnyvale deeded over by Lockheed, is government-owned. It houses the Navy's *Polaris* administrative group. Either the Naval Inspector of Ordnance, Capt. W. A. Hasler or his deputy, attends the meetings scheduled regularly each Monday morning in Raborn's office in Washington.

One of the most important divisions in the Navy building is Test Management and Operations headed by Lockheed's E. E. Christensen. The mission of this group begins when the first two parts of the missile are brought together and concludes when the launch data has been analyzed and changes are recommended. Included are the test facilities at Cape Canaveral where test firings are carried out.

F. J. Bednarz, responsible for development and design, said current *Polaris* flights are still development tests. He added that 22 of the first 26 launchings are considered successful. While no definite programs are in the works for extending the range of *Polaris*, operations analysts are doing "down-the-road" thinking, he said.

- **Research and development**—Heavy emphasis is placed on research and development with the center of activities at the Palo Alto laboratories.

Dr. Louis Ridenour is LMSD's chief scientist.

Efforts of research and development are in direct support of current prospects and as Smelt put it, "We consider ourselves the store house for the state of the art. Our teams move right from the laboratory into projects."

Over 2,600 persons are employed in research and development in Palo Alto, at Sunnyvale, Van Nuys, and at Menlo Park, Calif., where about 100 persons under Dr. Sidney Brown work in the advanced system organization on development of new ideas.

Lockheed, in addition to meeting military requests for proposals, devotes 25% of the effort and some $7-10 million a year to independent exploratory research. Some $30 million is invested in equipment.

Adhering to the idea that at present application is secondary to developments, Lockheed research and development teams are exploring the entire spectrum of missilery including nuclear physics, atomic and ionic physics, cryogenics, hypersonic aerodynamics, advanced propulsion, structures and materials, electromagnetic propagation and radiation, solid state electronics, communication theory, mathematics and computer research.

The main computing center is located here where data from *Discoverer* will be cranked into two Univac digital computors. Located at Sunnyvale, in conjunction with the Space Communications Laboratory, is one Model 1709 computor by IBM, with an additional one on order.

In processing data from *Discoverer* shoots, orbital data will be handled at Palo Alto and telemetry at Sunnyvale.

Smelt said the guideline in all R&D is to keep ahead of developments so that Lockheed is ready to move into the next phase, while supporting current projects.

Lockheed, through the Missiles and Space Division, is keeping abreast both human and scientific developments in efforts to produce better weapons for defense and launch man into space. Plans for the future are made with the conviction that the trend from manned aircraft to unmanned missiles will result in greater advances for commercial aviation and industry as a whole.

NYC Tests Missile Transport

by Frank G. McGuire

New York—A system of missile transport which reportedly reduces maximum shock during transit to 2g, or less than that encountered during air transport, has been devised by the New York Central Railroad. The method involves employment of large air bags inflated and located about the missile for maximum protection and cushioning.

As a result of tests, the railroad says its system is a "feasible solution to the reliable, versatile transport of missiles and related sensitive components" whether the missile is encapsulated or not. The method is immediately adaptable to widely varying sizes, shapes and weights of missiles and component containers.

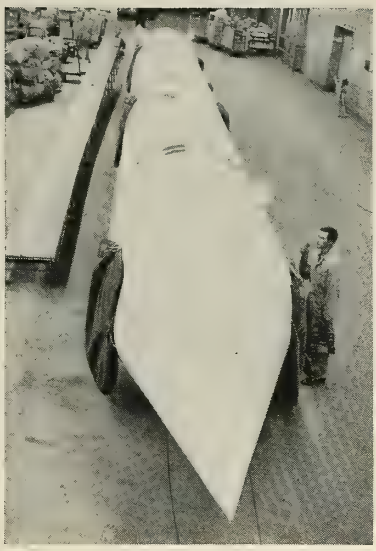
The car used in the tests was a standard baggage car having an internal length of 70 feet and eight-foot-square doors at each end. Missiles exceeding these dimensions can be accommodated in open-top cars. No alterations were made to the car used in the Central's tests.

Loading is accomplished by rolling the missile-supporting dolly along easily-removable tracks laid on the floor of the car. The tracks consist of steel angles to guide the dolly wheels. An industrial truck is used to move the dolly in and out of the car. After being placed in the car, the missile's weight is taken up by the inflated air bags and does not rest on the dolly.

Where a loading platform is not available, the missile, together with its normal support frame, is raised by a crane and swung into the car end first. When the front wheels on the support frame rest on the tracks in the car, one sling is removed and the other end of the missile supported by the crane until the rear pair of wheels on the frame rest on the tracks in the car.

The supporting air bags measure four by seven feet, and the side and lateral restraining bags measure four by five feet. Maximum working pressure of the bags is 10 psi, and burst pressure is 28 psi. Test information indicates that pressure loss due to leakage will not exceed 13% in 30 days.

The tests involved both regular road service and switching impacts at speeds up to 10 mph with three baggage cars having brakes set. After all switching, impacts and transport from Cleveland to Toledo, Detroit and return to Cleveland, the missile had moved less than two inches in any direction. No restraining devices were used. Dynamic displacement amounted to 18 inches during a 10 mph impact, then returned to almost-normal position.



WITH AIR PILLOWS deflated, the New York Central's replica of a large missile is pulled easily from a baggage car, under a new system of missile transportation which protects components for shock and acceleration.

The total weight of the Central's mock missile was 16,000 lbs. It measured 69′ 5″ overall length by 77″ cylinder diameter and had a 106″ fin span.

Sedov Compares Weights Of U.S./Soviet Rockets

Washington—Leonid I. Sedov of the USSR Academy of Sciences sharply criticized the inclusion of the *Atlas* weight in figures given for the *SCORE* "talking satellite," and in so doing, made some comments on Soviet rocket weights.

In an interview with a Pravda correspondent, Sedov declared that "to create a sensation, the weight of the U.S. satellite was combined with the weight of the four-ton carrier-rocket which placed it in orbit." He noted that the carrier rockets used in the Soviet satellite launchings also entered into orbit and stayed there for some time. He pointed out that the payload of the U.S. satellite is 1/57 the weight of the orbiting carrier rocket.

"The weight of the carrier rocket is no indication of the exploratory potentialities of the scientific apparatus container and of the payload the rocket can carry. That is why the weight of the carrier rockets for Soviet satellites was not published," Sedov stated.

He continued that "if one takes the relation of the weight of the payload to the weight of the carrier rocket to be equal to 57, as is the case for the U.S. satellite, it will be found that the weight of the last stage of the third Soviet satellite, which traveled around the earth for six months, must be more than 75 tons, instead of the four tons given for the U.S. satellite

"In as much as we are speaking about the weight of Soviet carrier rockets, I must tell you that although their weight, placed in orbit, was less than 75 tons, it was considerably more than four tons, and this applies not only to the third Soviet satellite, but also to the first and second. I can report that the weight of the first Soviet artificial satellite which was placed in orbit and circled the earth for two months was much more than four tons."

1,985 Basic Research Grants Budgeted for NSF

Washington—A record number of scientific basic research grants and graduate science student fellowship will be handed out in Fiscal Year 1960 if Congress approves the President's budget request for the National Science Foundation.

The budget asks for $160,300,000 for the Foundation, in comparison to $136 million appropriated in 1959 and $49,750,000 appropriated in 1958.

The Foundation's proposed budget would allow grants for 1,985 basic research projects to educational and other non-profit institutions by July, 1960. Some 1,760 basic research grants will have been funded by the end of June.

Some 2,893 graduate science students and teachers will continue their education under Foundation fellowships. This compares to 2,793 students and teachers for the previous year.

Another 28,000 high school and college science teachers would attend Foundation-supported science institutes with FY 1960 money.

Digitronics Corp. Sells Two Component Divisions

In view of the rapidly expanding volume of commercial data handling equipment, Digitronics Corporation has sold two of its component divisions.

The Digital Magnetic Tape Transport Division was sold to Fairchild Camera & Instrument Corp., while Eastern Precision Resistor Corp. purchased the Delay Line Division.

Missile Conference Set for May

WASHINGTON—The Second Annual National Missile Industry Conference, the country's most impressive gathering devoted to the missile business man, is entering final planning stages.

Spokesmen for the conference, to be held May 25-27 at the Sheraton Park Hotel here, expect a record attendance of key personnel engaged in the research, development, production, budgeting, utilization and publicizing of United States rocket and space exploration projects.

The conference, sponsored by the National Rocket Club of Washington, will be accompanied this year by the National Space Age Industry Exposition in the Sheraton Park's exhibition hall.

The three days of conferences will be under the leadership of committee chairman Lt. Gen. Ira C. Eaker (Ret.), vice-president of Douglas Aircraft Company. Selection of other key industry men for committee membership is being made.

• **Tentative program**—Two panel discussions—one in the morning, the other in the afternoon—are planned for each day of the conference. Here is the tentative program:

May 25—Morning—Government Roles and Responsibilities—NASA; moderator, Warren R. Smith, Fairchild Engine and Airplane Corp.

Afternoon: Congress and Astronautics; moderator, C. Lincoln Jewett, Arthur D. Little, Inc.

May 26—Morning: Government Roles and Responsibilities—ARPA and the Services; moderator, Erik Bergaust, MISSILES & ROCKETS magazine.

Afternoon: Small Business and Subcontracting; moderator: James J. Haggerty, Jr., Aircraft Industries Association.

May 27—Morning: Space Medicine and Industry; moderator: Robert D. Ladd, Marquardt Aircraft Co.

Afternoon: Business Forecasting; moderator: Edward W. S. Hull, Diversey Engineering Co.

Luncheons are scheduled for Monday, May 25, and Tuesday, May 26. On Monday, the Space Age Luncheon will tie in with the morning panel on the National Aeronautics and Space Administration. Chairman Norman L. Baker, associate editor of MISSILES & ROCKETS, has made arrangements to have a key NASA official as luncheon speaker and guest of honor.

The Missile Industry Luncheon on Tuesday will be a follow-up of the morning panel on the Advanced Research Projects Agency. One top ARPA official will address attendees. An award will be presented at each luncheon to persons who have made outstanding contributions in work falling under the cognizance of the agency being honored. Col. Nelson P. Jackson, USAF (Ret.), is chairman of the Missile Industry Luncheon.

Dr. Walter Dornberger will be speaker for Goddard Memorial Dinner

• **Exposition**—The National Space Age Exposition will be held in the Sheraton Park's exhibition hall throughout the conference under the auspices of the National Rocket Club. Manufacturers in the missile and space exploration program have been invited to participate along with ARPA, NASA, Army, Air Force and the Atomic Energy Commission.

• **Goddard Dinner**—Climaxing the conference and exposition will be the annual Dr. Robert H. Goddard Memorial Dinner on Wednesday evening, May 27. The Conference's only formal affair will include a reception honoring Mrs. Esther C. Goddard, widow of the rocket pioneer. Speaker for the dinner will be Dr. Walter R. Dornberger, Technical Assistant to the President of Bell Aircraft Corporation, last year's Missile Industry Luncheon guest of honor and speaker.

Program Chairman Erik Bergaust, editor of m/r, said that the three awards which will be presented at the Goddard Memorial Dinner (in addition to the two luncheon awards) will be the Borg-Warner Industry Award, presented by the Borg-Warner Corp.; the Robert H. Goddard Memorial Trophy, presented by American Aviation Publications (MISSILES & ROCKETS Magazine), and the Space Flight Achievement Award, presented by Daniel, Mann, Johnson and Mendenhall.

Dr. Goddard is to the Space Age what the Wright Brothers were to aviation. Born in Worcester, Mass., in 1882, Dr. Goddard became a teacher of physics at Clark University in Worcester. In 1914 he was granted two U.S. patents which are still basic to rocketry. From then until his death in 1945 he kept at rocketry through ridicule, New Mexico launching failures and finally a cancer operation after V-E Day.

• **NRC**—The National Rocket Club, sponsor of the National Missile Industry Conference and Space Age Industry Exposition, is "pledged to United States leadership in rocketry and astronautics." It was founded Oct. 4, 1957, as an informal luncheon club for exchange of unclassified information on rocketry and astronautics between members of the industry, press, government and the military.

In the spring of 1958 the club co-sponsored with the National Capital Section of the American Rocket Society the first National Missile Industry Conference and the Dr. Robert H. Goddard Memorial Dinner.

1-1.5 Meg Engine May be Operational in Six Years

NEW YORK—Thomas F. Dixon, chief engineer of Rocketdyne, estimates that the 1-1.5-million-pound-thrust single-chambered engine will not be available for operational use for at least six years.

Dixon, during the presentation of a paper entitled, "A look at Rocket Development for the Next Twenty-five Years," at the Institute of Aeronautical Sciences Symposium on Aero-Space Technology, said the single-chamber engine "will require tremendous development efforts, and larger test stands. Turbo-machinery capable of power outputs of small municipalities will be required to feed the propellants to the (combustion) chamber.

"Stable combustion chambers will have to be built with chamber densities many times that of existing engines. Plumbing, valves, etc., will be beyond the range of current experience."

The chambered cluster now under development at ABMA should be operational by 1960, Dixon said. The Rocketdyne engineer further estimated that a cluster of six of the 1-1.5-million-pound engines would not be available until 1970, with a cluster of 10-12 of the units operational by 1972.

Dixon projected his predictions still farther into the future with an estimate of nuclear rocket availability by 1975, an ion rocket by 1970 and a thermonuclear engine by 1985.

20 ICBM Squadrons in Budget

WASHINGTON—The 1960 Fiscal Year budget includes funds for initial and/or continued financing of 20 squadrons of U.S.-based intercontinental ballistic missiles—10 missiles to a squadron, a total of 200.

Nine of the squadrons will be of the Convair-built *Atlas,* the other 11 squadrons of the Martin-built *Titan.* A new guidance system will permit placing the *Atlas* on underground "hardened" sites, the same as *Titan.* First *Atlas* wing will be activated in Fiscal 1960, others to follow as fast as possible.

To make the money available for these 5500-mile missiles with their megaton-strength nuclear warheads, the Air Force drastically cut back procurement of B-52 bombers in the 1960 budget. Only 59 or 60 of the big bombers will be bought, enough to provide for the 14th wing expected to come into being during that era. At one time the Air Force was aiming at 20 or 21 wings.

- **Cutbacks**—In the Department of Defense portion of the budget, $6.795 billion is allocated for aircraft and $3.764 billion for missiles. Reduced spending for missiles is explained by the elimination of some (*Rascal, Regulus II, Goose, Redstone* and *Corporal*) and the phasing out of the IRBM *Thor* and *Jupiter.* Also, it was said, with much of the research, development and testing work finished, missiles will simply cost less to produce.

Broken down by services, the aircraft and missile rocket budget shows (in millions):

		Army	Navy	USAF
Aircraft				
	$6,795	$0,085	$1,866	$4,845
Missiles				
	$3,764	$0,406	$0,658	$2,700

The missile programs of the three services will be about as follows:

Air Force: *Atlas* and *Titan* programs accelerated, with *Titan* probably up 50 per cent and probably half a billion in ground support for the two; purchase of the *Bomarc* in operational quantities, including the new 400-mile production model; three-quarter billion hike in *Minuteman* funds; acceleration of air-to-ground ballistic missile; continued procurement of ground-to-air *Mace* and air-to-air *Hound Dog, Falcon* and MB-1 *Genie.*

Navy: Most importantly, continued development of *Polaris* weapon system, including building three more *Polaris* submarines and development of *Polaris* missile; buy *Sparrow III* and *Bullpup* for naval aircraft, *Tartar, Terrier* and *Talos* for the fleet. Continue development of *Eagle* and *Subroc.*

Army: Expanded program for ground-to-ground *Pershing* and *Nike-Zeus,* the anti-ICBM; Army will continue to buy *Nike-Hercules* for air defense and *Hawk,* low-level air defense.

The aircraft program of the three services:

Air Force: Will introduce first squadron of Convair B-58 Hustlers during 1960, buying about 40; will cut back Boeing B-52 purchases to 59 or 60 along with some 90 KC-135 tankers; support program includes purchase of turbojet and turboprop transports. North American chemical bomber program, as well as F-108 will be accelerated. Inventory will drop to 102 wings with just under 20,000 aircraft, 65% jets.

Navy: Will buy approximately 665 aircraft, maintaining about a 50% jet inventory totalling 9200 planes. The Seamaster program will be dropped. McDonnell's F4H-1 will go into production. Some 600 anti-submarine aircraft will be modified to include improved detection equipment.

Army: With only $87 million, Army will purchase fewer helicopters while fixed-wing aircraft will be mostly turboprop observation craft. Inventory on June 30, 1960 will be about 5363 aircraft—2558 helicopters and 2805 fixed-wing.

The National Aeronautical and Space Administration and the Advanced Research Projects Agency have budgets of $485 and $455 million respectively, although probably less than $700 million of this will go for actual space enterprises. The chief NASA space projects are:

Project *Mercury,* to place man in space; *Vanguard* and other space probes including the inflatable sphere and the cosmic ray satellite; million-and-a-half-pound-thrust engine; fluorine fuels.

European Group Studies Building U.S. Missiles

GENEVA—NATO has announced that studies have been made by a group of European manufacturers on the possibility of building U.S. guided missiles in Europe. The companies concerned, all designated by their governments, are: Ateliers de Constructions Electriques, Belgium; Telefunken, Germany; Finmeccanica, Italy; Philips, Netherlands; and Compagnie Thompson-Houston, France.

Some European sources have suggested that this group of manufacturers will be entrusted with the European production of the Raytheon *Hawk.* However, while it is known that *Hawk* is one of the projects studied by the European group, it is by no means certain that merely the member companies of the groups would be involved with the production of this missile.

U.S. Agencies Silent on *Lunik* Tracking

by Frank McGuire

WASHINGTON—If there is any official information available about the performance of the Soviet Union's space probe—*Mechta* (Dream)—United States agencies are not about to admit it.

Few agencies, with the notable exception of NASA's Jet Propulsion Labatories, will flatly say they positively identified the vehicle through radio contact, and no one actually will admit having sufficient contact to track it.

When asked specifically if any military or other government installation had succeeded in tracking and/or positively identifying *Lunik,* the Defense Department issued a reply saying only that the frequencies had been monitored and a report given to DOD by the stations involved.

Several other facilities say they heard something, but it was not on the announced frequency that *Lunik* transmitted on; or it was an altogether different signal from the one recorded by Radio Moscow and rebroadcast; or it was much too weak to have been identified as anything like telemetry.

RCA Communications, Inc. reported a signal monitored on 70.2 mc which sounded like telemetry but was not the same signal broadcast by Moscow. Also, 70.2 is not among the frequencies listed by Moscow as being in use aboard *Lunik.* RCA could name no one who had reported positive contact.

Smithsonian Astrophysical Laboratory withdrew an earlier statement that it had photographed the vehicle. A spokesman for SAL said: "To the best of my knowledge, it was not identified photographically. We originally thought so, but found it was not."

Jodrell Bank radio telescope in England was quoted as saying it had "probably" identified the vehicle, but a British Embassy official told m/r that "if Jodrell Bank had definitely identified the thing, someone here (at the embassy) would certainly know about it, and we have heard nothing."

Tape recordings of the signals heard by various facilities are being analyzed by electronics experts experienced in telemetry to attempt a solution to the question.

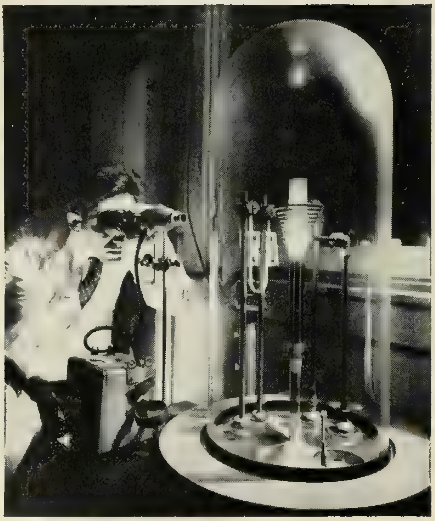
The entire situation has become of great interest, not because there is any conclusive evidence in either direction, but because there is not.

CAPABILITIES FOR DEFENSE

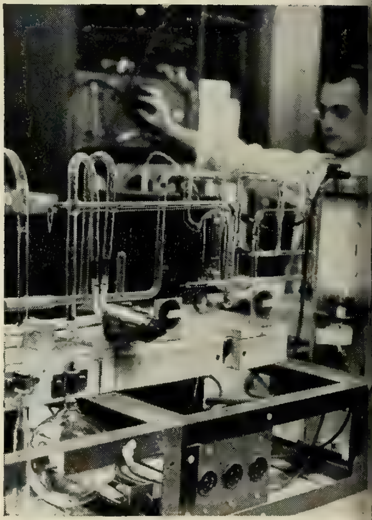
Westinghouse is spending $185 million for research and development in 1959

HERE ARE SOME CURRENT PROJECTS . . .

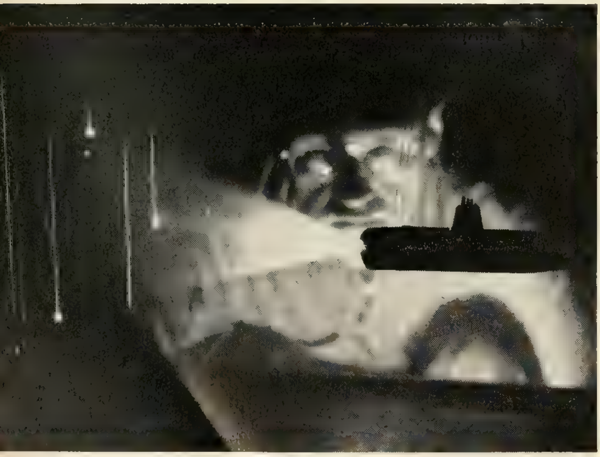
HIGH TEMPERATURE ELECTRICAL INSULATION. Effective for long periods at 500° C—eventual applications to 1000° C now contemplated. Demonstration motor shown above is running red hot. ***Aircraft Equipment Department, Materials Engineering Departments, and Research Laboratories***



SPECIAL METALS. Westinghouse spearheads research in refractory alloys with one of the country's largest programs in special metals. Westinghouse is nation's principal supplier of a number of special defense-application metals. ***Materials Manufacturing Department, Aviation Gas Turbine Division and Lamp Division***

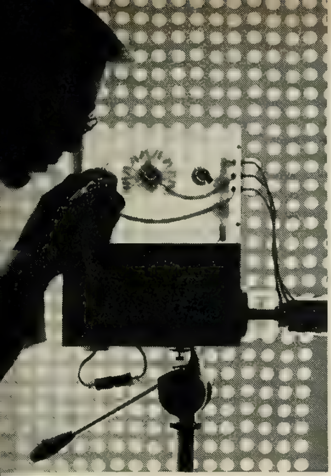


HIGH-VACUUM RESEARCH. Extensive high-vac research conducted since 1947. Current area investigation include electrical and chemical pu ing in ultra high-vacuum range and compo development for large high speed pumping syst Results being applied in advanced electronic de development. ***Air Arm Division and Rese Laboratories***

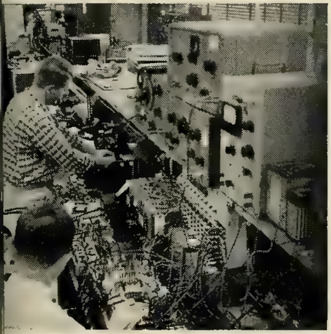


UNDERWATER SONICS. Current Westinghouse projects being conducted in laboratories and at sea are investigating various types of "scatterers" and their effect on the underwater transmission of sound. Also under development: acoustical torpedo controls and an acoustical mine identification system. ***Ordnance Department and Research Laboratories***

NON-ROTATING 360° RADAR ANTENNA. Only the feed point moves. Princi involved will permit economical construction of very large high gain scann antennas. Application of inflation techniques will permit lighter-weight long-ra air-transportable radar. Working models already built and evaluated. ***Electro Division and Research Laboratories***



IT AMPLIFICATION, through electron bom-
dment induced conductivity. Extremely sen-
e. Principle especially useful for satellite
nnaissance devices. Efficient working mod-
have been developed. *Electronic Tube*
sion, Astronautics Institute and Research
oratories



E-DOPPLER RADAR is in advanced devel-
nt in three major areas of application at
inghouse. Research is continuing to open
ew potentials. Westinghouse is the
owledged leader in this field. *Air Arm*
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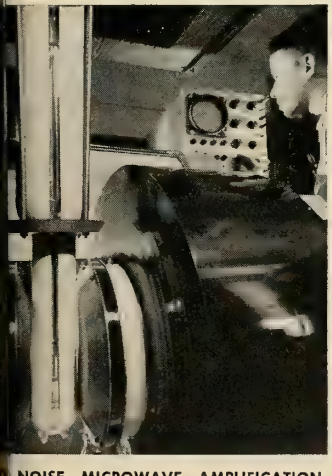
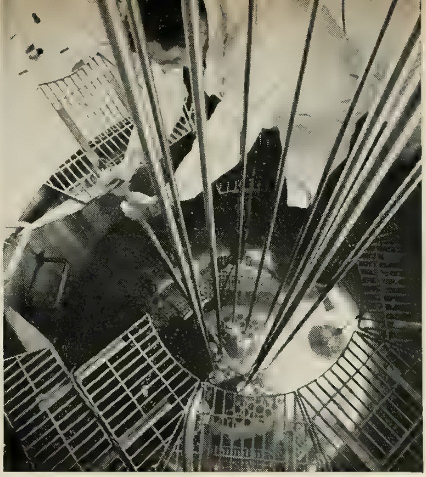
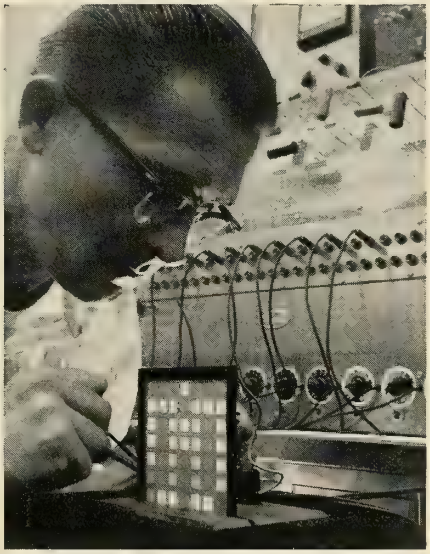


-NOISE MICROWAVE AMPLIFICATION.
inghouse scientists have developed vari-
low-noise solid-state amplifying devices,
MASER and non-linear reactance types.
ess in recent years was speeded by prior
s of research in low-temperature and solid-
physics. *Air Arm Division and Research*
ratories



NUCLEAR RESEARCH. At the Westinghouse Testing Reactor, engineers are preparing high intensity radiation tests on a wide range of materials to determine their structural, chemical, and nuclear stability. This is a necessary prelude to using these materials in certain atomic power applications now under development. *Atomic Power Department*



NEW DATA DISPLAY DEVICES. Electroluminescent cells, individually controlled, form flat picture. Model has oversize cells for demonstration; latest techniques produce cells only 1/16" across. Similar tote board display, capable of high-speed read-out of digital inputs, in production. Both devices can be erased instantly or retained and studied for long periods. *Electronics Division, Rayescent Lamp Department and Research Laboratories*

INFRARED research projects include: *thermal imaging* — working models in advanced development; *ultrasensitive doped crystal detectors* — advanced test models; *photo-electric magnetic detection* — working model. *Air Arm Division, Semi-Conductor Department, Materials Engineering Departments, and Research Laboratories*

THERMOELECTRICITY. Westinghouse recently developed the first efficient material to produce electricity directly from heat at high temperatures (1100° C). In addition, other thermoelectric material under development can be used for cooling purposes, including very light-weight applications. Forty Westinghouse scientists now on this project. *Materials Engineering Department and Research Laboratories*

For information on these and other research projects, write to Mr. E. W. Locke,
Director, Customer Relations, Westinghouse Defense Products Group,
1000 Connecticut Avenue, N.W., Washington 6, D. C.

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YOU CAN BE SURE... IF IT'S Westinghouse

Black Knight Engine Described

by Anthony Vandyk

LONDON—British security has permitted details to be released on the Armstrong Siddeley Gamma rocket engine used in Britain's *Black Knight* re-entry test vehicle. It has a total thrust of 16,400 lbs at sea level, rising to nearly 19,000 lbs. outside the earth's atmosphere due to drop in back pressure.

In November, 1955, the Royal Aircraft Establishment initiated development of *Black Knight,* a re-entry test vehicle for which it had produced a preliminary design based on existing Gamma engine components developed by the R.A.E. Rocket Propulsion Department at Westcott (now the Rocket Propulsion Establishment). To obtain adequate thrust for the vehicle, four Gamma units were required and it was realized that with some modification these could be used to control the vehicle in a very simple manner. The R.A.E. retained design authority and appointed Saunders Roe as the main contractor for the vehicle; and Saunders Roe placed a contract with Armstrong Siddeley for the rocket engine.

Armstrong Siddeley began the design of an engine incorporating four Gamma units, modified from the original RPD design, in order to obtain experience of their behaviour. While entirely satisfactory for experimental purposes, the units required further development before they could be considered suitable for use in the re-entry test vehicle.

In the Armstrong Siddeley Gamma engine the four combustion chambers are arranged uniformly around the central vehicle support and are mounted on trunnions so that they may be rotated about axes that radiate from it. A hydraulic actuator, fitted to each chamber to control the angular movement, receives instruction from the guidance equipment.

- **No roll**—The vehicle is not intended to roll during flight and therefore two diametrically-opposed chambers are rotated together to control pitch, and the other two to control yaw; to correct any tendency to roll, all four chambers are rotated in the same direction. Pitch and yaw are arbitrary terms for this vehicle because its flight path is almost vertical.

The combustion chamber trunnions are hollow, and through the inboard trunnion hydrogen peroxide (HTP) is pumped into the outer shell of the combustion chamber. To cool the inner shell, which contains the flame and would otherwise rise to 2500°C, the HTP is passed through a clearance between the two shells before it enters a catalyst pack at the top of the chamber. This pack consists of silver-plated nickel gauzes and in it the HTP is decomposed into a mixture of superheated steam and oxygen with which kerosene ignites spontaneously.

The kerosene is fed into the chamber through its outboard trunnion and is admitted into the combustion chamber as soon as a pressure rise indicates decomposition of the HTP. Prior to this instant, nitrogen is blown through the fuel passages to prevent reaction in them between HTP and the incoming fuel. The nitrogen for this is obtained from a ground installation, which is disconnected automatically as the vehicle rises from the launcher pad.

- **Common manifold**—Each combustion chamber is fed with propellants by its own turbo-pump unit, the four units being joined at the center by a common HTP manifold to form a rigid cross which is attached to the structure of the vehicle at each of the fuel pump suction elbows. The centrifugal impellors of the HTP and fuel pumps are mounted at opposite ends of the same shaft that carries the turbine rotor.

HTP decomposed in a separate catalyst pack provides a jet of hot gas which impinges on the axial flow turbine to drive the pumps. To start the engine, HTP is supplied under pressure for this purpose from a ground installation which is disconnected automatically as the vehicle rises from the launcher pad. By this time the HTP pump pressure is large enough to supply the HTP for the turbine through a control valve.

The complete engine compartment weighs some 700 lbs.

Missile Shapes and Ladies' Figures

A REMARKABLE SIMILARITY between some of the shapes required for rocket and missile components and for milady's current attire has been noticed by Spincraft, Inc., Milwaukee spinning firm specializing in the former field. So they put an artist to work with these results and conclusions. The trapeze look is inspired by the conical spinning on the *Honest John*. The sheath is a missile nozzle component. The chemise is a spun cylinder for a missile first stage.

Space 'Progress' by 1969?

by Paul N. Means

WASHINGTON—How far into space will man have ventured by 1969?

This question was posed to the nation's leading space experts by the staff of the House Astronautics and Space Exploration Committee. Their answers are contained in a committee report released recently.

Man during the next 10 years, according to the consensus of the experts, will have set foot on the moon, will be sending expeditions to Mars and Venus, will attempt "soft landings" of instrumented packages on other planets, will have orbited a large space station which itself will stage rockets toward the moon and planets, and will be using earth satellites for commercial communication and meteorological purposes.

The experts caution, however, not to expect too much progress in the immediate future—and too little progress later.

"A common error" (in forecasting progress), according to George L. Haller, vice-president of General Electric Co., "is that of being too optimistic about what can be achieved in a few years and too cautious about the developments to be expected in 30 years."

Before the 20th century expires, the experts see man traveling at close to the speed of light, and using such esoteric devices as nuclear power, ion rockets, solar boiler rockets, plasma jets, photon rockets, magnetic propulsion and braking systems, and solar sails.

Predictions in any phase of science is hazardous, but the experts point out that progress in space research seems to have outstripped predictions in the past.

Most agreed that the rate of progress lies less with technology than it does with the attitude of the people.

• **Motivation**—"The hero of this age," according to George S. Trimble of the Martin Co., "will not be the space traveler, but rather the man or men who successfully figure out how to motivate 170 million American people actively to do battle with a part of their environment that they just began to hear about, that they really did not know was important."

Specific estimates of the date which man will first set foot on the moon varied from seven to 15 years.

Dr. Herbert L. York, new Director of Research and Engineering for the Department of Defense, thinks man can first set foot upon the lunar dust in "just about 10 years (perhaps in as little as seven, if a very high priority were placed on this goal.)"

Others, including ABMA's scientific director Wernher von Braun, believe that manned flight around the moon is possible within a decade, but that a two-way flight to the moon, including landing, would take place a few years thereafter.

The experts were in disagreement as to whether propulsion systems and space knowledge would be sufficient to send man to Mars and Venus within a decade, but there was general agreement that these planets, and also Jupiter would have their atmospheres probed by instrument payloads by 1960.

• **Short distance this year**—To send man into space for a short distance will be accomplished in the very near future—possibly in 1959. And within five years, according to Brig. Gen. H. A. Boushey, Air Force Director of Advanced Technology, orbital refueling and restaging will be under way.

According to Gen. Boushey, 1965 will see manned maintenance, repair, and resupply space vehicles in use for military, commercial and scientific purposes.

By the end of the next decade, man will have constructed and orbited a large space station, and will be preparing for controlled space flight. According to Dr. Walter R. Dornberger, rocket expert for Bell Aircraft, such vehicles up to the end of 1969 "will be mainly up to 650 miles this side of the radiation cloud at operation times of two or three weeks.

Within the next 10 years, space vehicles will be used for communications, television, weather, and astronomy.

Communications satellites could establish a truly global TV service with vital political, commercial, and cultural consequences, according to English scientist and author Authur C. Clarke. According to Clarke, the impact of television in Asia and Africa (made possible by communication satellites) could be overwhelming. "It may well determine whether Russian or English is the main language in the future . . . the TV satellite is mightier than the ICBM."

Accurate world weather predictions, according to the experts, and some resulting control of weather will be affected in the next decade through the use of meteorological satellites.

Other commercial applications of satellites includes the formation of a global post office, which could deliver mail almost instantaneously.

• **New fuels**—Beyond the next decade, there will be new fuels developing 10 to a 100 times a million pounds of thrust, enveloped in packages able to withstand a temperature of 10 million degrees. The experts do not underestimate the obstacles in producing such propellants and envelopes, but are confident that such technical capability is within our grasp in the 20th Century.

The state of the art in propellants in 1969, according to JPL's director Dr. William H. Pickering, will be such that reliable chemical engines will have thrusts of several million pounds, prototype models of atomic rocket engines will be undergoing static tests, ionic propulsion systems will be in the advanced experimental stage, and more efficient and reliable solar-energized power sources having an almost indefinite lifetime will be produced.

What are the potentials in space? The assumptions, conjectures and speculations that the experts make include some wilder than Jules Verne or the creator of Buck Rogers have conceived.

Dr. Eugen Sänger of the Technical University of Stuttgart talks about an ultimate space weapon similar to the "death ray." She describes this device as a "stationary ultraviolet searchlight" which might exert a radiation pressure by means of high-energy beams and thus be able to destroy "flying objects up to a distance of several hundreds of miles in a fraction of a second."

A relativity check with atomic clocks, according to NASA scientists, could prove or disprove time-gravity aspects of relativity, such as whether or not a 1,000 years would have passed on earth in the course of a 22-year space flight to a star a thousand light years away at a speed close to the speed of light.

France Forms Committee For Astronautics Research

PARIS—The French government has established a committee to evaluate the nation's potential in space research and to oversee any programs which may develop as a result of the committee's proposals and recommendations.

An annual report will be submitted to the government by the committee, which is composed of: the Chairman of the Committee of Scientific Action for National Defense; the President of the Office Nationale d'Etudes et de Recherches Aeronautiques (French counterpart of NASA); the head of the Observatory of Paris; the head of the National Committee for Scientific Research; the head of the administration supervising universities and special schools; the head of Cultural and Technical Matters of the Department of Foreign Affairs; and a representative of the Ministry of Finance.

Estimating Missile Expenditures — —

Unfortunately there are no definitive answers — — but with forward planning company resources could be directed to proper business success.

by Douglas S. Evered
Missile Division, North American Aviation, Inc.

Los Angeles—If businessmen involved in the U.S. missile effort knew what the levels and applications of future missile funds would be, they could strengthen their competitive positions and bolster their capabilities.

Unfortunately, definitive answers to these questions are not forthcoming.

The military cannot answer them with great certainty because far more than purely military considerations enter into deciding how much shall be spent and for what projects. For example, most people will agree that generous funding of missile projects is an outcome of East-West tension—but how can we be sure that the Soviets will not switch to a political-economic offensive? Such a move might dictate re-directing our national effort and diverting funds into economic countermeasures.

Then again, economy moves sometimes take hold in Congress or the Administration, causing program cuts or stretch-outs. Still another factor is the occurrence of some technological breakthrough such as thermonuclear development, which paved the way for a large-scale ballistic missile effort by making practical warheads available.

These and other factors add up to a formidable series of obstacles in the way of reliably predicting future missile business.

Nevertheless, a good deal of consideration must be given to the questions of how much and for what. A company must spend sizable amounts of its own money today studying projects which will provide its business five to ten years from now.

• Prologue—In predicting how much missile money will be available, it is sometimes useful to look back over the history of missile expenditures and draw inferences for the future. Curiously enough this approach, though neglecting other factors, produces results which coincide with many authoritative estimates by aviation and missile economists. Statistically, it would appear that by 1965, for example, we may expect an annual expenditure of $6.6 billion for missiles (bases, ground electronics and *Polaris*-carrying submarines excluded).

Similarly, analysis of the past use of missile funds shows a relationship between the airframe, guidance, propulsion, nose cone and ground support equipment. Projecting into the future with the same statistical methods, it would appear, for example, that missile frame expenditures will be about $2.08 billion by 1965.

The trouble with such statistical projections is that their accuracy, if it occurred, would be coincidental rather than well-founded in the determining factors. Because they fail to take into account legislative attitudes, the international climate, changing operational concepts, technological developments and the state of the economy—to name salient considerations—such projections are unacceptable to the critical appraiser.

• Projection model—We can find interesting solution to the prediction problem by constructing a model using selected choices among the variables. For example, in the matter of the international climate, we can look at the next five years as a period with or without a global conflict, with or without local conflict, or with or without an arbitrated East-West settlement.

An acceptable assumption might be to anticipate no global conflict but a high probability of local conflict.

As for legislative attitudes, a selection could be made between Congressional attitudes which would result in a sizable increase in appropriations—for example, an incease to $55 billion dollars annually in keeping with the recommendations of the Rockefeller Report, attitudes which would stabilize appropriations around current levels, and attitudes which would promote sharp reductions.

Obviously, the choice here is related to the choice made for the international climate, which governs legislative attitudes and resulting appropriations. A favored choice for the model would be that of appropriations stabilized between $40 and $42 billion annually for the next five years.

• Difficult to predict—Changing operational concepts will undoubtedly appear and will be difficult to predict, being an outcome both of new technological developments and of demands imposed by international commitments. However, several changes are incipient and should be included in the model. These reflect increased concern with local conflicts, orbital type military activity, the submarine threat, and defense against ballistic missiles.

A backward glance at the history of missile expenditures in terms of the desired operational capabilities is helpful in constructing the model. It takes time to achieve capabilities, and the span of effort and accompanying expenditures generally extend into the future. In other words, existing programs must be projected as part of the process of assembling a reasoned prediction of future missile business.

Each area now receiving effort must be looked at in terms of continuing operational requirements. For example, will the air-to-air missile field expand, contract or remain about the same during the next five years? The big determinant here is the future of the manned interceptor as opposed to the surface-to-air missile. With the exception of the planned long-range interceptor, the F-108, it appears that the surface-to-air missile will steadily take over the interceptor role.

Although this might seem to herald contraction of the air-to-air missile market, increased performance requirements of future air-to-air missiles such as *Eagle* and *GAR-9* probably will offset the decrease in the number of missiles actually put into inventory and the expenditures involved.

• Low-level air-breather—The surface-to-surface air-breathing missile field has declined as preference for ballistic delivery has grown. Apart from the dark horse of an extremely low-level weapon system, most competent observers predict the decline will continue.

Air-to-surface missiles are expected to expand. With the steady improvement in techniques of bomber interception, the role of the ASM as an aid to penetration and as a stand-off weapon through the IRBM range is almost certain to grow. Moreover, ASM's probably will be used more and more as armament for fighter bombers and helicopters in local conflict problems.

Long-range surface-to-surface ballistic missile programs, with the recent addition of *Minuteman,* now number six. Until they are operational, say by 1963, rising expenditures are inevitable. However, it appears that land-based IRBM's may be de-emphasized considerably, beginning in 1960, due to the political undersirability of relying on overseas bases.

Only Britain and Italy have shown willingness to accept IRBM's and the total number of missiles involved is less than one hundred. By contrast the increasing attractiveness of the ICBM as a deterrent weapon, and the possibilities for more sophisticated versions, underline the probability that *Minuteman* will not be the last of the line.

Surface-to-surface tactical missiles are entering their second generation. Emphasis is being placed on mobility, simplicity, improved C.E.P.'s and wider use in tactical problems of the Pentomic Army. Gaps in the spectrum of tactical missiles will have to be filled in the next few years. Expenditures will probably increase to cover at least two new programs in addition to the replacement of existing systems.

- **Expansion for SAM**—Surface-to-air missile expenditures face continuing expansion under the strong pressure for AICBM capability. A logical extension of air defense is anti-satellite work. We should anticipate almost a doubling of surface-to-air missile spending by 1965, assuming technical solutions to the AICBM problem. However, a considerable portion of such funds could go to those who solve the detection and discrimination problem.

The anti-submarine warfare role of the missile is beginning to come into its own. *Subroc* is the first of this breed and further effort undoubtedly will accompany a breakthrough in the detection problem.

This leaves the area of orbital-type military activity. Here, the further one looks into the future the harder it becomes to separate manned and unmanned efforts. However, there is little doubt that orbital activity will stimulate the missile business. Payload vehicles aside, it is clear that the booster vehicle production will increase substantially in the next five years. Boosters to be powered by the recently-initiated large engines development programs have yet to become the subject of actual projects. These will be forthcoming and will constitute a big share of large future expenditures.

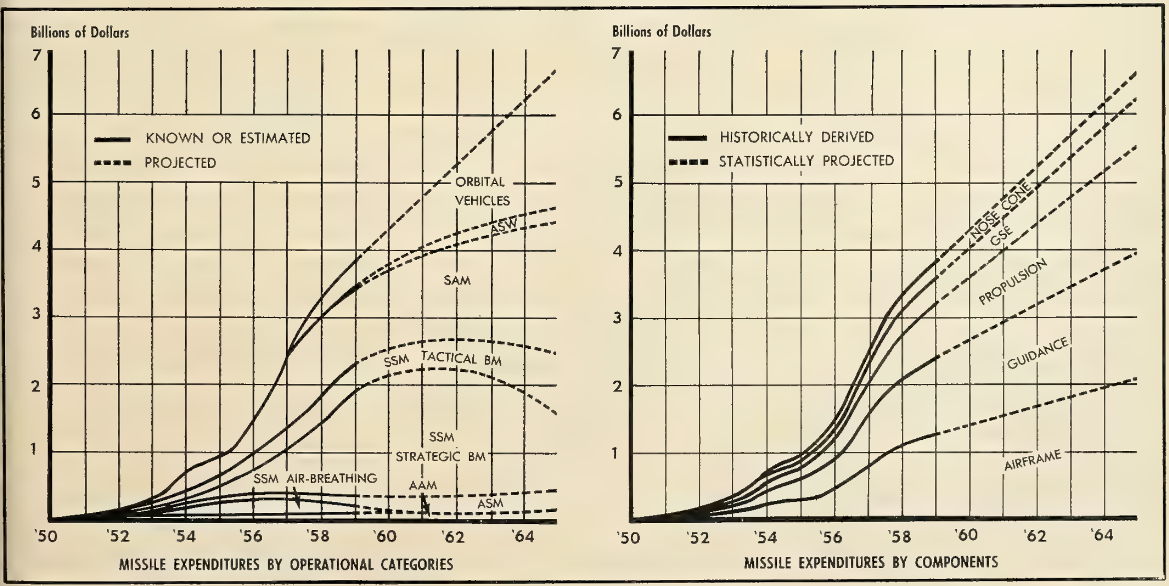
In describing the features of a business prediction model it must be pointed out that many of the nuances which would be fed into such a model for missile industry usage have been left out of this discussion. (For example, classified technical or intelligence data would be very important. And of course these have been omitted). But from the standpoint of comparing purely quantitative estimating methods with those including qualitative considerations, the results of the two analyses show that the levels of expenditures predicted are almost certain to be reached.

- **Component spending**—As for statistical projections of components expenditures, there are strong reasons to doubt that the historical division of expenditures will remain the same. The trend towards solid propellants is already taking a share of the frame segment of expenditures because the motor cases are themselves part of the frame. Similarly, greater sophistication in guidance techniques—such as the blending of inertial, mid-course and terminal guidance requirements for long-range missiles—will change the proportion of funds going in that direction.

It must be concluded that the component spending picture in the future will change considerably. Contrast, for example, the GSE costs of a fully-hardened ICBM base with those of an air-launched IRBM system. In many operational situations the actual weapon delivery method can hardly be described as being fully resolved.

The significance of these considerations to a company in the missile business cannot be overemphasized. Only with forward planning can company resources be directed into the proper areas with a reasonable probability of success.

Projected Expenditures for Missiles



MISSILE EXPENDITURES BY OPERATIONAL CATEGORIES

MISSILE EXPENDITURES BY COMPONENTS

Chemical Industry Expands for Astronautics

by Alfred J. Zaehringer

WASHINGTON—Although there were strong recession tides during most of 1958, the U.S. chemical industry—sparked in part by the growing missile business—spent a whopping $1.4 billion to expand its facilities. This compares to $1.7 billion in 1957.

In this construction, there was a notable trend toward bolstering research and development centers plus expanding the chemical specialties field for missiles and rockets. The chemical industry is increasingly feeling the impact of the missile and space programs.

The accompanying table shows specialized propellant facilities for chemical expansion in the missile-space field. Some 58 new facilities have been built at a cost of many millions of dollars. Dollar costs are shown only for larger items.

All material used was gathered from such Washington sources as the American Chemical Society, Business and Defense Services Administration, and the Manufacturing Chemists Association.

Prominent chemical construction related to the missile field in 1958 included expansion in air cryogenies, specialized solid and liquid propellants, and expanding missile metals and materials for missile electronics.

- **Air cryogenics leading**—A large portion of the overall expansion was devoted to enlarging the Nation's production capacity for air products. Biggest item was for LOX, followed by liquid nitrogen and argon. Helium, still in government hands, remained in tight supply for now and the near future.

For example, Air Products, Inc., built four plants in Pennsylvania; Air Reduction Sales constructed plants at Acton, Mass., Denver, Kansas City, and Lorain, O. Linde Co. built facilities at Aurora, Minn. and Fontana and Pittsburgh, Pa. National Cylinder Gas Co. facilities are at Compton, Calif., Erie and Philadelphia, Pa., while Southern Oxygen Co. built a facility at Bladensburg, Md.

Not all of the LOX expansion will go into missiles, but much of the new construction will be in areas that could be accessible for future missile development.

- **Specialized propellants follow**—Notable among liquid propellant expansion were construction of facilities for producing liquid fluorine and a new plant for high-strength hydrogen peroxide. Most liquid plant capacity, however, was in the area of high-energy fuels—the boron hydrides. Two solid propellant plants were also built.

Not reflected were the newcomers to the solid game under ARPA contract: American Cyanamid, Dow Chemical, Esso Research & Engineering and Minnesota Mining & Manufacturing.

Some highlights from the expanding facilities for producing new metals and materials is best illustrated by the following:

Alco Products, Inc., nuclear research lab at Schenectady; Allegany Ludlum Steel Corp., special steels research lab at Breckenridge, Pa.; Beryllium Corp., metal production plant at Hazelton, Pa.

CBS Laboratories, research lab at Stamford, Conn.; E. I. DuPont de Nemours & Co., delrin and teflon resin plant at Parkersburg, W.Va., and North Carolina silicon facility; Foote Mineral Co., silicon metal facility at Exton, Pa.

General Atomic Div., nuclear research center at San Diego; GE's R&D center for nuclear energy at Pleasanton, Calif.; Merck & Co., silicon facility, Danville, Pa.; National Res. Corp., tantalum facility at Cambridge.

Olin Mathieson aluminum mill at Hannibal, Mo.; Sylvania research lab at Towanda, Pa.; Union Carbide Plastic Co., liquid epoxies plant at Marietta, O.; and National Distillers niobium and tantalum pilot plant at Cincinnati.

SPECIALIZED PROPELLANT FACILITIES

COMPANY	LOCATION	COST $ MILLION	NOTES
ALLIED CHEMICAL CO.	Metropolis, Ill.		Elemental fluorine.
AMERICAN CYANAMID CO.	New Castle, Pa.		Ammonium nitrate plant.
AMERICAN POTASH & CHEMICAL CORP.	Aberdeen, Miss.	4.5	Sodium chlorate.
APACHE POWDER CO.	Benson, Ariz.	1	Anhydrous ammonia: 30 tons/day capacity.
CALLERY CHEMICAL CO.	Lawrence, Kan.	4	High-energy boron fuel plant.
	Muskogee, Okla.	38	Tonnage boron fuel plant.
FOOD MACHINERY & CHEMICAL CORP.	Buffalo		Becco Chemical R&D facilities for government & armed forces.
GIRDLER CONST.	Model City, N.Y.		Hydrogen plant for Olin Mathieson boron fuel plant.
	Muskogee, Okla.		Nitrogen, hygrogen, carbon dioxide plant for Callery Chemical.
GRAND CENTRAL ROCKET CO.	Redlands, Calif.	1.725	Mixing, assembly, test & offices for solid propellants. Capacity of 1 million lb./month.
HERCULES POWDER CO.	Wilmington, Del.	0.75	Concentrated nitric acid: 50 tons/day.
HOOKER CHEMICAL CO.	Columbus, Miss.	1	Addition to sodium chlorate plant. Production up to 22,000 tons/year.
LINDE CO.	Linden, N.J.		High-purity hydrogen.
MISSISSIPPI CHEMICAL CORP.	Yazoo City, Miss.	1.8	Ammonia & nitric acid plant. 30 tons/day ammonia, 150 tons/day nitric acid.
MONSANTO CHEM. CO.	Monsanto, Ill.		Amines.
OLIN MATHIESON CHEMICAL CORP.	Model City, N.Y.	46	Organic boron fuel.
	Niagara Falls, N.Y.	4.5	HEF-2 boron fuel plant.
PENNSALT CHEMICALS CO.	Portland, Ore.		Ammonium perchlorate plant.
	Portland, Ore.		Sodium chlorate plant.
PETROLEUM CHEMICAL INC.	Lake Charles, La.		Anhydrous ammonia, 100,000 tons/year.
SHELL CHEMICAL CORP.	Norco, La.		Hydrogen peroxide plant.
STANDARD OIL CO. (IND.)	Seymour, Ind.		Expansion of solid propellant R&D facilities.
VALLEY NITROGEN PRODUCERS, INC.	Helm, Calif.	9	Anhydrous ammonia: 150 tons/day capacity.
WYANDOTTE CHEM. CORP.	Geismar, La.	26	Ethylene oxide & intermed. plant, 40 million lb./year.
	Wynadotte, Mich.		Propylene oxide plant.

Some significant areas of chemical expansion.

Theodolites Determine Azimuth for *Jupiter*

Optical-electronic combination provides method for automatic alignment and monitoring of inertial guidance systems.

NORWALK, CONN.—One of the most important tools in the hands of the people responsible for launching inertially guided missiles, such as the *Jupiter,* is the azimuth alignment theodolite. This tool, basically an optical-electronic system consisting of an intricate arrangement of lenses, mirrors, beams of light and a closed electronic circuit, provides a method of automatically aligning and monitoring the inertial guidance system.

By lining up the missile's inertial guidance system with predetermined and highly accurate directional "bench marks," the theodolite system becomes an indispensable means of setting one of the most crucial elements in the programmed trajectory of a long range missile—a correct azimuth heading.

The direction the missile will fly in azimuth is determined by the physical orientation of the missile motion measuring devices at the instant of launch. A basic requirement of the *Jupiter* guidance system is to orient these measuring devices properly at launch, and maintain an accurate space-fixed reference during the entire guided portion of the flight. This requirement is met by the missile inertial platform manufactured by the Ford Instrument Company.

The guidance package contains the sensing devices used by the missile, and acts as the basic source of intelligence for the guidance system computers.

Since the missile system is entirely free of external sources of guidance from launch to impact, the azimuth command given to the missile in the form of orientation of the inertial platform is irrevocable after the missile leaves the pad. It is therefore of the utmost importance that this command be given accurately, in order to take full advantage of the guidance possibilities of the inertial platform.

After the missile has been aimed along the correct azimuth line, the properly aligned guidance system continues to perform its vital functions.

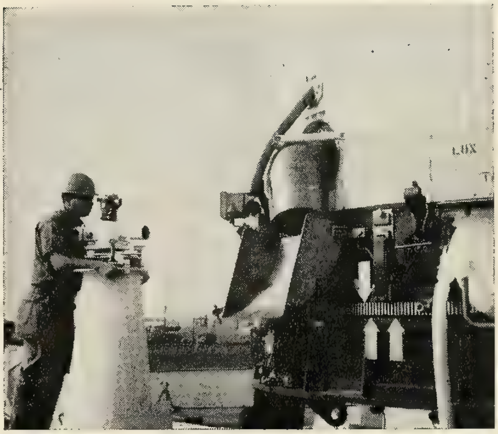
- **Determines variables**—Before engine cutoff, the guidance system, by means of sensitive accelerometers and computers, determines the variables necessary to solve a cut-off equation. When these variables satisfy the equation, signals shut down all thrust. The platform on which these accelerometers are mounted are precisely orientated in inertial space by the gyros that were automatically aligned by the theodolite before launch. These precise acceleration-measurements are used to calculate the missile's speed and position.

Seconds of arc error cause significant flight path error when dealing with terrestrial and celestial distances. The importance of critical azimuth adjustment is stressed by the fact that only a 20-second error (one second of arc equals 1/1,296,000th part of a circle) in the azimuth heading of a 1500-mile-range missile means an off-target impact of about 0.15 miles. It can be appreciated that these infinitesimal adjustments for correct alignment can only be accomplished through the use of optics. Optics work within tolerances of 1/10th of a wave of light and a wave is equal to .000011 of an inch.

Alignment theodolites are now operational at a number of missile sites and are also being used in the production, testing and alignment of stable platforms.

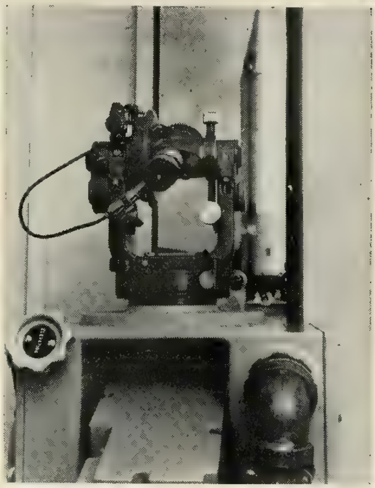
The Perkin-Elmer Azimuth Alignment Theodolite was developed expressly for the problem of highly accurate reference of inertial guidance systems with given geographical references. The theodolite automatically detects discrepancies in the alignment of the basic monitored equipment by continuous observation of the reflections from a mirror mounted on the stable platform of the inertial guidance package. Such rotational discrepancies cause error signals which are applied as corrective signals to the drive elements of the monitored equipment via a closed loop system between theodolite and missile.

The monitoring optical system consists of two modulated light sources, a telephoto lens as the objective, a beam-



SHORT range Perkin-Elmer theodolite monitors auxiliary prism in missile base during weather conditions which interfere with primary theodolite.

MODEL 523 Theodolite seen through window in front of Craig hut.



UPPER portion of same theodolite seen from inside of hut.

dividing "Vee" prism and a photomultiplier tube.

The light from two glow discharge lamps—electronically modulated at 400 cycles in phase opposition—in the monitoring system is reflected from a mirror or prism mounted on the stable platform on the guidance system. The two lamps are each imaged at the focal plane of the telephoto objective by separate condenser systems, and a prism-shaped mirror reflects the beams along the optical axis of the objective lens.

• **Angular displacement**—The resultant signal produced by the photomultiplier is a function of the angular displacement of the monitored mirror from the autocollimated or "squared on" position. This signal is also 400 cps, whether in phase or 180 degrees out of phase, with the reference voltage, depending on the direction of deviation.

The tie-in to the geographical reference is achieved by use of a high-quality survey theodolite incorporating an accurate azimuth circle and sighting telescope. The desired angle between the sighting or "reference" line of sight and the "monitoring" line of sight is set off using the azimuth circle. The "zero" setting of the circle is determined by autocollimating both systems from a common test mirror.

If the monitored mirror is rotated in azimuth even "slightly," the returning beams will not be centered on the optical axis and, depending on the degree of rotation, will pass through a slit—ground and polished on the apex of the prism—and strike the photomultiplier. In this manner, an error signal output is produced which, in phase relationship, is representative of the direction and magnitude of azimuth deviation.

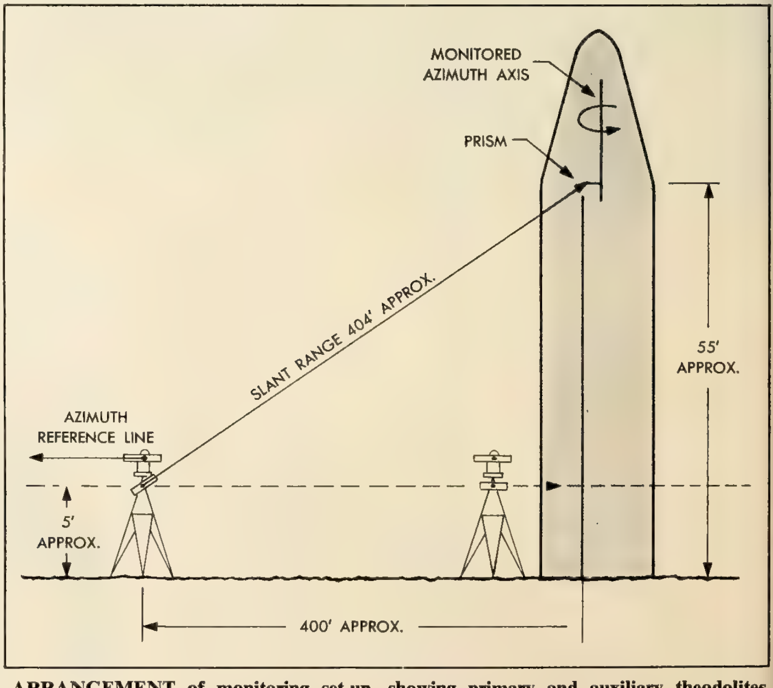
Error signals are fed to the stable platform to drive the platform back to conformity with the beam of light and thus the correct azimuth heading. The entire closed loop relationship, therefore, is automatically self-correcting. As a result, these signals counteract any tendency of the platform to move away from the very important established heading. The platform is controlled automatically within very small limits and over relatively long periods of time. The error signals generated by the theodolite may also be recorded to obtain long-term data for use in making corrective adjustments.

The Intermediate Range Theodolite for the *Jupiter* manufactured by Perkin-Elmer Corp., represents a variation from other alignment theodolite units in production by the company.

The monitoring problem imposed by the *Jupiter's* dimensions, position, and guidance system required the particular physical location of the theodolite in respect to the monitored axis. The reference line of sight is established with a standard surveying theodolite slightly modified for mounting on the top of the main instrument housing.

Aperture and focal length of the *Jupiter* theodolite is increased to 4" and 36" respectively because of increased distance requirements. Electronic unit consists of amplifier, preamplifier and power supply-modulator.

The major sections of the instrument are constructed of mechanite castings for rigidity and stability over the wide temperature ranges encountered. All exposed small parts are stainless steel for corrosion resistance. The the-



ARRANGEMENT of monitoring set-up, showing primary and auxiliary theodolites.

odolite is mounted on a special pedestal.

• **How it works**—Characteristics of the output signal are as follows:

1. *Phase*—in phase or 180° out of phase with respect to the 115-volt 400-cycle reference voltage supply within 10°.

2. *Maximum Output Impedance*—500 ohms.

3. *Frequency*—400 cycles sinusoidal voltage synchronized with the 115-volt 400-cycle reference voltage supply.

The power requirements are as follows:

400 watts—60 cycles or 400-cycle 115 volts power source.

1.0 watt—400-cycle 115-volt signal supply.

Two theodolites are used with the *Jupiter*; the "primary aiming" intermediate range model 523, and an "auxiliary" short range model 169. The short range unit is stationed 3 to 4 feet from the foot of the missile and sends beams to an auxiliary prism monitoring unit (with the same heading as the top prism) in the base of the *Jupiter*. This monitoring unit is directly connected to the launching ring on which the missile is positioned. A second auxiliary monitoring prism is also attached to the launching ring at an angle representing a second target point.

Purpose of the short range theodolite—expendable due to its proximity to missile blast during launch—is to take over alignment adjustment in the event of poor weather conditions which might interfere with or distort the beam path to the nose section.

New, Compact Unit Converts Data in Flight

New York—A small, compact analogue-to-digital converter about the size of two quart milk cartons has been announced by Gulton Industries Inc., of Metuchen, N.J. The company claims the development means that for the first time information on speed, radiation and temperature can be accurately converted and telemetered from satellites, missiles and rockets while in flight.

Advantages of the converter are its small size and weight (less than seven pounds), an estimated accuracy of 0.1% and an operating temperature range from about 20° to 175°F. Gulton spokesmen said in-flight conversion would permit immediate action on such vital factors as missile pitch, without going through time-consuming conversion on the ground. The converter can handle 12 items of information, through 12 channels.

Coupled with the company's new physiological medical transducers, the converter can serve as an electronic "doctor" to measure reactions of men and animals to high speed and other aspects of space travel. The new transducers, also small in size, include a breathing rate transducer, heart and pulse rate indicator, skin temperature probes and a galvanic skin resistance transducer.

The company built the converter under contract from a government agency it declined to name. A spokesman said the company has orders for 150 converters.

Tube Said to Run Years On Weak Solar Power

New York—A new electronic tube unveiled here recently may lead to earth-satellite radios that will run for years on power from weak solar batteries, its makers claim.

The manufacturers, Tung-Sol Electric, Inc., of Newark, N.J., say the device is the first major improvement in vacuum tubes in 30 years. They expect it to be available to the armed forces within a few months and to the general public within a year.

The principle of the new instrument was discovered in 1952 by Dr. Dietrich Dobischek, a scientist at the U.S. Army Signal Research and Development Laboratory, Fort Monmouth, N.J. Tung-Sol has been working with the Signal Laboratory on the project since 1956.

It operates with a cold cathode as an electron emitter. All other tubes use hot cathodes to boil electrons out, and thus use a great deal more power. The new tube is said to use only a tenth the power of standard tubes when operating, and to "idle" on five millionths of a watt. It needs no warm-up period such as standard tubes require, but it has a built-in tungsten-filament "starter" to give it the boost it needs to start functioning.

Laboratory tests at Tung-Sol indicate that the tube will withstand the high radiation of space and operate over a temperature range from liquid air to red heat. Transistors, which are also cool and require little power, cannot withstand such extremes of radiation and temperature. Tung-Sol believes it can build cold-cathode tubes rivalling transistors in tiny size.

A drawback of the new tube is that it operates only at 300 volts or above. But its total electric consumption is said by the makers to be small enough that weak solar batteries can operate it.

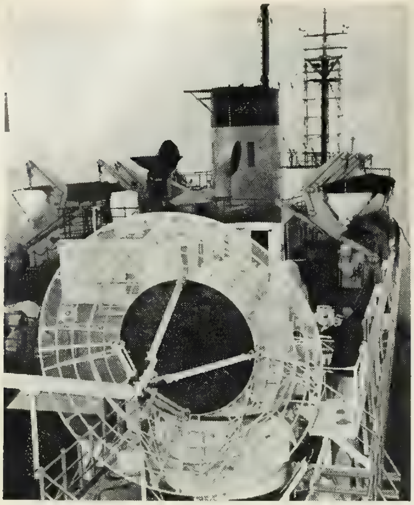
The tube's cold cathode is nickel-coated with magnesium oxide—dried milk of magnesia. A high-voltage field, rather than heat from high electric power, causes the electron flow from the cathode. Components of the cold cathode, unlike those of the hot cathode, are said to be physically and chemically inert, which accounts for the tube's long-wearing qualities.

Tung-Sol hopes that the new tube will lead to improvements in home radio and television, in radar, in many military applications, and in such fields as lighting and television screens.

Electronics Buying Shows Quarterly Increase

Washington—Defense electronics procurement during the first quarter (July-September 1958) of the current fiscal year dropped from the fourth quarter of fiscal year 1958, Electronics Industries Association, reports. The figures for the first quarter of fiscal year 1959, however, show a $32 million increase over the corresponding period.

Using a specific formula to extract the portion of military spending for electronics from all major defense procurement categories, EIA reports total expenditures in the July-September 1958 period at $958 million, indicating a decrease of $229 million—or about 20%—from the $1,187 billion reported for the fourth quarter of fiscal year 1958.



"LARGEST" tracking radar antenna afloat.

CENTRAL CONTROL room of Army's "missile measurement ship."

3000-Mile Radar May Be on Tracking Ship

by Peer Fossen

BALTIMORE—The Army's "missile measurement ship" or "floating laboratory," the S.S. American Mariner, is en route to her destination somewhere in the South Atlantic. Equipped with the latest and most advanced radar, other electronic, and optical missile tracking and in-flight measurement gear, the vessel is said to be capable of collecting the most precise data yet obtained at sea.

According to spokesmen from Radio Corporation of America—systems management contractor—the vessel will work "far off regular sea lanes" within the Atlantic Missile Range which extends from Cape Canaveral some 5,000 miles southeast to Ascension Island. She can operate independently for 40 days, and will carry a scientific staff of some 50 scientists, engineers and technicians in addition to the ship's crew of 51 men.

RCA Service Company has supplied experienced electronic operations personnel from its missile tracking activity at Canaveral. Barnes Engineering Co. is prime contractor in charge of design and operation of non-radar measuring.

• **Potent radar**—The S.S. American Mariner carries two sets of high-power tracking radars, which RCA calls the most accurate tracking radar in the world. Neither RCA nor the government is willing to reveal the exact tracking range of the radar, but a distance of "hundreds of miles" is indicated. A Department of Defense release, however, says the scientific staff will continue precision observation and data collection of a missile performance "from its ascent to remote altitudes in space, through all levels of the earth's atmosphere to the final plunge to earth or sea."

If this is the case, it is fair to assume that the vessel might carry radars capable of tracking over ranges exceeding 1000 miles, and if ICBM tests are in the program, radars with 3000-mile capability could be involved. Development work on 3000-mile radars was announced more than a year ago.

• **To close gap**—A small fleet of vessels like the S.S. American Mariner, equipped with long-range radar, could fill the gap in our detection of northbound missiles—such as ICBM's launched from the Antarctic—and activate in-time defenses.

The S.S. American Mariner's role as a link in anti-missile defense is also emphasized by the part Barnes Engineering Co. has in her instrumentation and operation. Barnes was one of the companies responsible for the success of last summer's Operation *Gaslight*—considered a major accomplishment in anti-missile research (m/r, July 14, p. 14). The company's field measuring crew on board the ship is expected to amplify and extend the *Gaslight* research.

One piece of equipment developed by Barnes for the *Gaslight* experiment was a meteor-type spectral camera using six individual cameras to attain a view of approximately 70° vertically and 100° horizontally. Other instruments included specially-designed radiometers.

The S.S. American Mariner project is sponsored jointly by the Advanced Research Projects Agency and the U.S. Army Ordnance Missile Command. Lt. Colonel Harry W. Stulting, of Redstone Arsenal, is the official Government representative on board the ship.

Information obtained by the scientific staff of the missile measurement ship will be shared by all branches of the Armed Services. Valuable information on missile firings from the Atlantic Missile Range will be contributed by the Air Force. Agencies participating in the planning and direction of this comprehensive missile and satellite measurement project include the Advanced Research Projects Agency of the Department of Defense, and the Army Rocket and Guided Missile Agency of the Army Ordnance Missile Command.

when and where

FEBRUARY

14th Annual Technical and Management Conference, Reinforced Plastics Div., Society of the Plastics Industry, Inc., Edgewater Beach Hotel, Chicago, Feb. 3-5.

IRE, AIEE 1959 Solid State Circuits Conference, University of Pennsylvania, Philadelphia, Feb. 12-13.

Conference for Manufacturing and Engineering Management, Computer and Data Processing in Industry, Purdue University, Lafayette, Ind., Feb. 12-13.

Heat Transfer Div. of American Society of Mechanical Engineers, Third Annual Symposium on Thermal Properties, Purdue University, Feb. 23-26.

1959 Engineering Exposition, Balboa Park, San Diego. For information, contact exposition office at 422 Land Title Bldg., San Diego. Feb. 26-Mar. 1.

MARCH

IRE, AIEE and Association for Computing Machinery, 1959 Western Joint Computer Conference, Fairmont Hotel, San Francisco, March 3-5.

Institute of the Aeronautical Sciences, Flight Propulsion Meeting (classified), Hotel Carter, Cleveland, March 5-6.

Second Western Space Age Conference and Exhibit, Great Western Exhibit Center, Los Angeles, March 5-7.

Western Space Age Conference and Exhibit. For information: Domestic Trade Dept., Los Angeles Chamber of Commerce, 404 South Bixel St., Los Angeles, March 5-7.

Gas Turbine Division of the American Society of Mechanical Engineers, Turbine in Action, Cincinnati, March 8-11.

Third Annual Shock Tube Symposium, Old Point Comfort, Ft. Monroe, Va. For details: Armed Forces Special Weapons Center, Kirtland AFB, Albuquerque, N.M. Attn.: SWRS R.R. Birnkoff, March 10-11.

American Society for Metals, 11th Western Metal Exposition and Congress, Pan-Pacific Auditorium and Ambassador Hotel, Los Angeles, March 16-20.

The American Rocket Society, 1959 Sectional Meeting, Daytona Plaza Hotel, Daytona Beach, Fla., March 23-25.

Institute of Radio Engineers, National Convention, Coliseum and Waldorf-Astoria Hotel, New York, March 23-26.

Polytechnic Institute of Brooklyn's Ninth International Symposium, Auditorium, Engineering Societies Bldg., New York, March 31-Apr. 2.

Society of Automotive Engineers, National Aeronautic Meeting, Hotel Commodore, New York, March 31-Apr. 3.

APRIL

Conference on Electrically Exploded Wires, sponsored by the Thermal Radiation Laboratory of the Geophysics Research Directorate of the Air Force Cambridge Research Center, Somerset Hotel, Boston, Apr. 2-3.

1959 Nuclear Congress, Municipal Auditorium, Cleveland. For information: Engineers Joint Council, 29 West 39th St., New York, Apr. 5-10.

American Welding Society, 1959 Welding Show and 40th Annual Convention, International Amphitheatre and Hotel Sherman, Chicago, Apr. 7-10.

Air Force Association's World Congress of Flight, Las Vegas, Nev., Apr. 12-19.

American Society of Tool Engineers, Annual meeting, Schroeder Hotel, Milwaukee, Apr. 18-22.

American Rocket Society, Man-in-Space conference, Hotel Chamberlain, Hampton, Va., Apr. 20-22.

Institute of Environmental Engineers, 1959 Annual Meeting, LaSalle Hotel, Chicago, Apr. 22-24.

American Rocket Society, Controllable Satellites Conference, Massachusetts Institute of Technology, Cambridge, Apr. 30-May 1.

missile business

by Reed Bundy

Two major union leaders have warned that the missile and aircraft electronics industries may be headed for disaster unless they get the same minimum wage regulations the Government applies to the aircraft industry.

Al Hayes, president of the International Association of Machinists, and Walter P. Reuther, president of the United Auto Workers, told the U.S. Labor Department that "failure to include missiles and specialized electronics systems in the definition which will be used to establish a new minimum wage for the industry could seriously hurt the industry, its employes, and ultimately, our country's race for supremacy in missiles and space vehicles.

"It is entirely possible," they declared, "that a wrong decision by the Department . . . could demobilize many aircraft plants and throw scores of thousands out of work."

The IAM and UAW represent about 500,000 aircraft and missile workers. In this case, they have joined with the Aircraft Industries Association in asking the Labor Department to extend regulations under the Walsh-Healey Act—now covering aircraft manufacturers—to production of all missiles including electronic systems and subsystems used in missiles and aircraft.

House investigators are blaming the weapons system concept for what they consider unfair Pentagon treatment of small contractors. The Hebert Investigations Subcommittee of the House Armed Services Committee is expected shortly to begin a thorough probe of military procurement.

Rep. Carl Vinson (D-Ga.), chairman of the parent committee, says he's afraid there may be "too many loopholes" in the law. He reported that of five million contracts awarded by the Department of Defense last year, only 275,000 resulted from competitive bids. He wants a "tightening up" of the law to prevent so many negotiated contracts.

A committee spokesman said the coming investigation will take a hard look at what he called "soaring costs" under the weapons system procurement concept—and air charges that industry receives a virtual "guaranteed profit."

More than 50% of the dollars spent on missile systems go for ground support equipment, according to B. J. Meldrum, special assistant to the general manager of Chrysler's Missile Division. In a recent Detroit speech, Meldum said present missiles often are the simplest elements in their own systems. He said the picture will change, however, when solid and prepackaged liquid propellants are further developed.

An up-to-date list of missiles and missile contractors has been published by The Value Line Investment Survey, of New York. It shows 75 missiles, compared to 61 last July, and 59 prime contracting companies, compared to 45 six months ago. The investors concede that because of security regulations, the list is not necessarily a complete one.

The list carries the name of each missile accompanied by the manufacturers of its frame, powerplant and guidance system.

RCA has begun building a major missile and radar center at Van Nuys, Calif., and expects to begin moving in by late summer. The new facility, located on a 50-acre tract 15 miles northwest of Los Angeles, will include engineering, production and administrative buildings to handle RCA's growing weapons and radar business. The firm is prime contractor for the Air Force's BMEWS and holds a contract for the electronic check-out and launching system for the *Atlas*, under sub-contract to Convair.

Sylvania Electronic Systems, a Division of Sylvania Electric Products, Inc., will move late this month into a new 30,000-square-foot building in Waltham, Mass. The building will house the division headquarters and a new systems fabrication facility.

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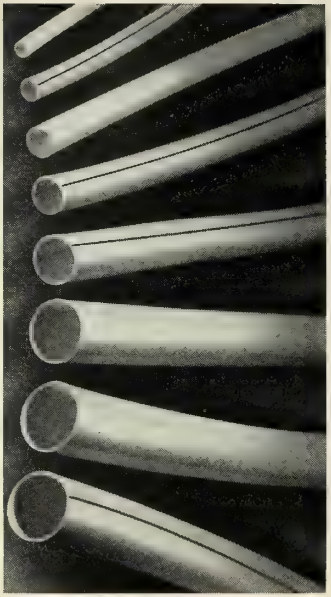

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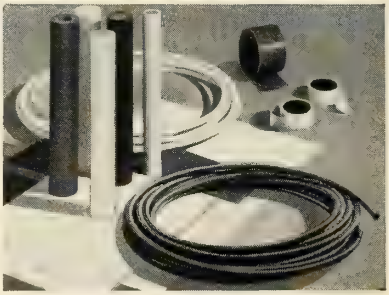

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book reviews

ROCKET TO THE MOON by Erik Bergaust and Seabrook Hull, 270 pp., $5.95, D. Van Nostrand Company, Inc., Princeton, N.J.

A hard-hitting book written in absorbing journalistic style by two editors of MISSILES AND ROCKETS magazine. The first chapter especially is devoted to an examination of why we were not first in space. It presents the facts as the authors see them and they pull very few punches.

Most of the book, however, is devoted to the moon and to moon exploration. The authors do a very fine job of giving space to various competing theories concerning the origin of the surface features of the moon.

Moving away from the purely scientific controversies, it is on the question of the military value of the moon base where opinion again becomes dominant. Here the authors are careful to quote experts from both sides, from those who argue that the lunar base will be valuable for controlling the earth, and that we cannot afford to let anyone else establish a lunar base, all the way to the other point of view which denies that the lunar base would have any appreciable military value.

Since scientific exploration of the environment of the earth and of the lunar surface has to come first in any case, much of the book is devoted to a discussion of the problems that face us. There is an excellent and well-informed discussion on the rockets, followed by a chapter called "What's the Delay?"

Here again the authors state opinions on how a space program ought to be run. They illustrate very effectively and amusingly their point that much could have been done by now with available rockets; they manufacture an imaginary occurrence in which the "Cool-Cola Company" launches a rocket at the moon from a merchant ship in the Pacific using nothing but available commercial rockets.

This, the authors say, could have been accomplished in 1956. But actually the first attempt to send a vehicle close to the moon was made two years later in August, 1958. This exciting event is described in great detail and the reader feels that he is a spectator and participant.

All of this, plus the many quotations from authorities, make the book topical, exciting and controversial. The reader may not agree with every point of view put forth by the authors but he will have a hard time putting the book down once he has started.

Dr. Fred Singer

missile people

The National Aeronautics and Space Administration has appointed **Ernest W. Bracket** Director of Procurement and Contracting. NASA's laboratories will continue to let many of their own contracts, but Bracket will direct overall policy. He was formerly Contract Specialist and Consultant to the Director of Procurement and Production at Air Materiel Command Headquarters, Wright-Patterson AFB.

Dr. Wernher von Braun has received the nation's highest civil service award —the Gold Civil Service Medal. President Eisenhower made the award to the Army's ballistic missile expert for "brilliant leadership" in satellite and weapons programs. He told Von Braun: "We're proud of you."

Ten top scientists and engineers, have been selected by the staff of the Pacific Missile Range at Point Mugu to act as members of the Pacific Missile Range Advisory Committee. They will help PMR and Navy in Planning long-range objectives, functions, and capabilities, and in evaluating performance and progress. First meeting of the committee will be Feb. 18-20. **Dr. A. B. Focke,** Technical Director of PMR, will act as chairman. Committee members are: **Dr. W. R. Brode,** Science Advisor, Department of State; **Capt. Walter S. Diehl,** USN (Ret.), Consulting Engineer; **Dean William L. Everitt,** School of Engineering, University of Illinois; **Willy A. Fiedler,** Head of XN Development Technical Staff, Lockheed Aircraft Corp.; **Dean L. E. Grinter,** dean of Graduate School and Director of Research, University of Florida; **Dr. C. C. Lauritsen,** Professor of Physics, California Institute of Technology; **Dr. Fred C. Lindvall,** Chairman of the Division of Civil, Electrical and Mechanical Engineering and Aeronautics, California Institute of Technology; **Dr. Wm. B. McLean,** Technical Director, Naval Ordnance Test Station, China Lake, Calif.; **Capt. Grayson Merrill,** UNS (Ret.), General Manager, Fairchild Astrionics Division; **Dr. Royal Weller,** Vice President of Engineering, Stromberg-Carlson Co.

Several new assignments have been announced in the management of United Aircraft Corp.'s Research Department to expand work in basic research and the physical sciences. **Wesley A. Kuhrt** is chief of research activities; **Richard C. Molloy,** chief of technical operations; **George F. Hausmann,** chief research engineer; **Irving Twomey,** chief of test operations; **Stuart L. Crossman, Jr.,** chief of computational services, and **Arthur E. Wethebee, Jr.,** departmental services.

space age

by Norman L. Baker

Project Confusion—If U.S. progress in space development is measured by the number of projects, we are on our way. A pathetic facet of our mad dash in so many apparently uncoordinated directions is the confusion encountered in attempting to wade through the plethora of project names. For example: Project *Mercury* is the title of NASA's man-in-space (MIS) program. ARPA will experiment on its own with vehicles of Project *Discoverer* although ARPA and NASA are supposedly involved in a coordinated program. The flight of Gordo the monkey in the nose of a *Jupiter* IRBM, without a project designation, was apparently not an official experiment of either agency's programs. Yet the animal test is unquestionably an important phase of the overall man-in-space agenda. Project *SCORE* on the other hand is related to the experiments that will be conducted during the Project *Discoverer* program but seems to have been given a separate definition and task as a prestige afterthought.

Now it's projects within projects—Confusion's latest catalyst is the establishment of Project *Centaur.* Sponsored by ARPA, *Centaur* is the design, development and construction of an upper stage for the *Atlas* booster slated for incorporation in advanced phases of the *Discoverer* and *Mercury* programs and Project *Midas.* Project *Centaur* will also make it possible to send payloads the size and weight of *Lunik* (or *Mechta*) to the moon, Venus and Mars.

The recon satellite program meanwhile has almost lost its identity (perhaps intentionally) by its habitual designation switch. It began with the title of *Big Brother,* then went through such names as *Pied Piper, Sentry, Baby Sentry, Discoverer* and finally Project *Midas*—most ludicrous of all (Midas was the stupid, greedy, mythological king who was given the golden touch).

ARPA's big push—The United States' first mega-thrust-plus space vehicle, utilizing clustered *Jupiter* engines, has been designated *Juno V.* Reportedly with a cluster of 8-10 engines, it may be 23 feet in diameter and 72 feet long. Total thrust may be about 1.3-1.5 million pounds. Recovery of the booster would be attempted by parachute descent at sea. Propellant tanks would provide buoyancy after expulsion of propellant residue and automatic sealing of outlets.

First flights of animals and men in the *Mercury* program may be made in the nose of modified *Jupiters.* Short-range ballistic flights (similar to the Gordo experiment) reportedly are scheduled to start before summer. This program should follow closely the parameters selected for the earlier ABMA Project *Adam.*

***Lunik* progress report**—On Jan. 15 the Soviet's artificial asteroid reached its perihelion. According to Russian calculations the vehicle was 90,914,400 miles from the sun after traveling 18.63 million miles from the earth. This places *Lunik's* closest approach to the sun inside the earth's orbital path and 585,600 miles nearer the sun than the first position calculations released by Russian scientists. *Lunik's* higher orbital velocity (approximately 20 miles/sec. for *Lunik* compared with earth's current velocity of about 18.7 miles/sec.) will, in a few weeks, swing it out beyond the orbit of the earth. (Correction of estimated *Lunik* data appearing in this column of Jan. 12: At *Lunik's* aphelion, Mars will be trailing the probe by approximately 105 degrees.)

An American astronaut has really projected his prognostications into the cosmos by hinting that perhaps the Russians will attempt to recover *Lunik's* payload, as physical proof of the achievement, at its next close approach to the earth sometime in 1964.

propulsion engineering

by Alfred J. Zaehringer

Ceramic reactors, now under design development, may play a big role in future *Kiwi* atomic rocket engine. This approach would, conceivably, allow an operating temperature of 3000-5000F—giving an I_{sp} in the 300-600 second range.

New fluorine oxidant, N_2F_4, is being suggested by Ethyl Corp. as a potent rocket chemical. More performance gains are seen to stem from oxidizers than from fuels.

Annular diffuser for ramjets, is the subject of a Navy patent for dumping boundary layer air to prevent uneven burning and consequent varying thrust. An annular scoop about the inlet diffuser vents the boundary air. Remaining "smooth" air goes straight through for combustion.

New "impossible" solid propellants will be shaping up. Farrington Daniels of the University of Wisconsin reports two new solid propellant possibilities. Both are based on the fact that solids can "store up" additional energy when bombarded by nuclear radiation. This energy, plus that released on regular chemical reaction, would be obtainable in combustion. Oxidant crystal solids could, thus, store more energy. Some crystals, for example, have had their energy content increased by over 100 calories per gram. Then, fuels such as graphite on neutron exposure could store up an extra several hundred calories per gram. Eventually, by such a radiation process, the energy content of a solid propellant could be increased 10-100% merely by irradiation. This, plus normal chemical energy would be released on combustion. If stability could be effected, present high energy solids in the 275 second range could be upgraded to 300 seconds. It is possible that the additional energy "kick" could be applied just before firing if large fluxes are obtainable. Such "hot solids" might even be able to compete with the exotic solids.

Aging of solid propellants has taken on a new importance with the coming operational models of *Polaris* IRBM and *Minuteman* ICBM. According to a Stanford Research Institute study, field replacement of the motor would be the optimum way to eliminate performance variations due to solid propellant aging. Design, thus, should allow for an easily replaceable motor.

Fuel-binders being offered by Goodrich Chemical Co. are based on "Estane" polyurethanes and "Hycar" (copolymer of butadiene and carboxylic monomer). Both castable and extrudable polymers are offered for solid propellant production. The urethanes contain over 26% oxygen and 7-9% hydrogen. The company maintains a composite solid propellant program at its Development Center at Avon Lake, Ohio with basic research being carried out at its Research Center in Brecksville, Ohio.

Continuous blender, called the Impingatron, looks good for certain solid propellant processing since it is designed for mixing a large amount of solid (oxidant) with a small amount of liquid (polymeric fuel-binder). A product of O'Brien Industrial Eqpt. Co., of San Francisco, the machine can handle 400 cubic feet of mix per hour. Solid particle sizes handled vary from micron range to 20 mesh.

Big business in small rockets. The Denver firm of Model Missiles reports that in less than one year, it has produced 200,000 of its Type A-4 solid motors that deliver one pound of thrust for one second. Other models are available.

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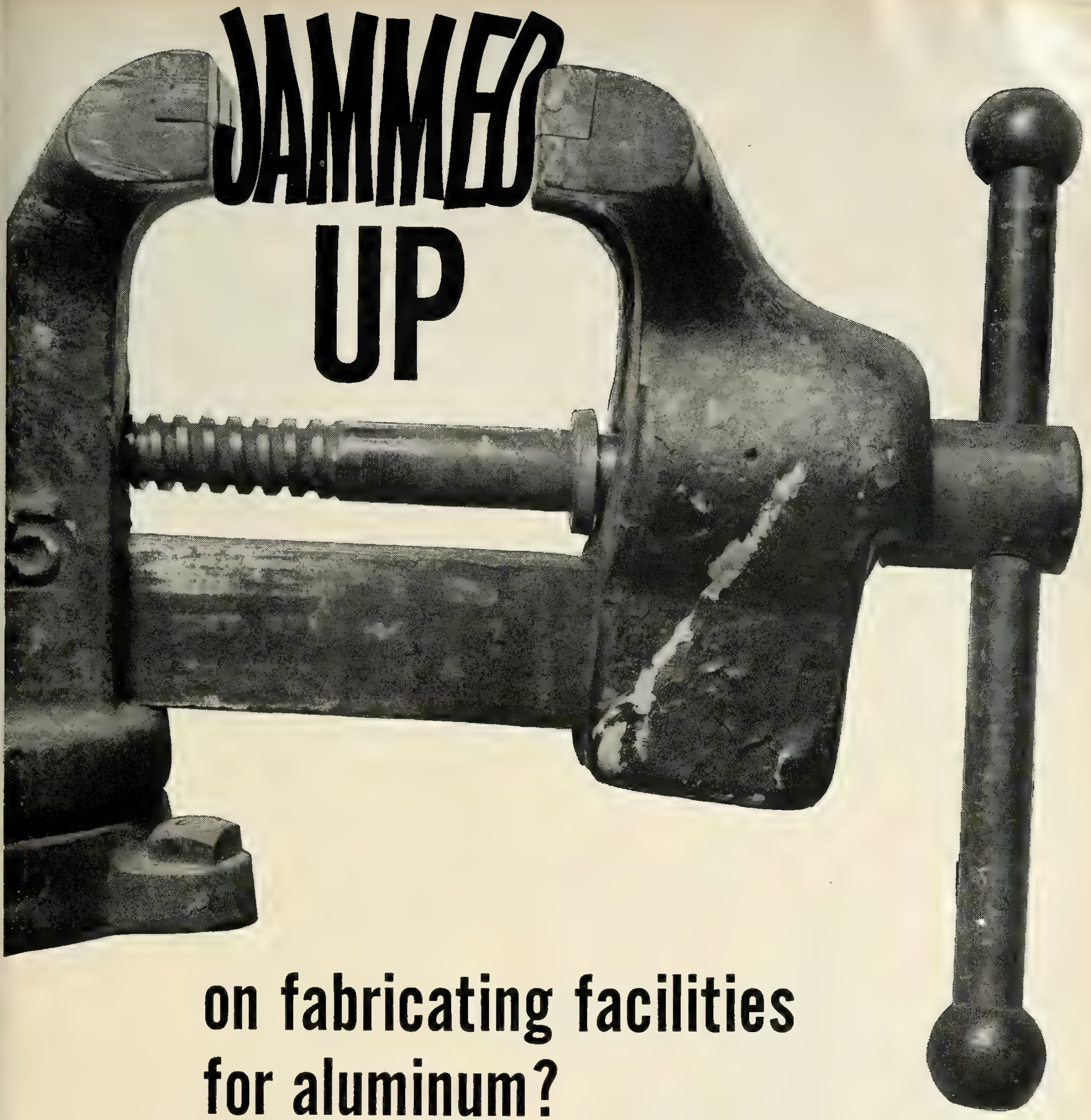

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contract awards

ARMY

$13,000,000—**Sperry Rand Corp.,** Salt Lake City, for missile.

$9,000,000—**Sperry Rand,** for missile R&D.

$3,795,730—**North American Aviation, Inc.,** Canoga Park, Calif., for design and development (three contracts).

$2,383,173—**Thiokol Chemical Corp.,** Redstone Div., for unspecified number of improved *Sergeant* solid propellant rocket motors. (Contract awarded for NASA.)

$947,640—**California Institute of Technology,** for research and development (two contracts).

$910,000—**Waltham Precision Instrument Co.,** Waltham, Mass., for instruments.

$585,000—**North American Aviation, Inc.,** for rocket engines.

$442,072—**Firestone Tire & Rubber Co.,** Los Angeles, for repair parts.

$296,435—**General Electric Co.,** Phoenix, for computation facility operation.

$143,033—**Dale Products Inc.,** Albuquerque, N.M., for testers.

$127,580—**Interstate Electronics Corp.,** Anaheim, Calif., for transponders.

$120,818—**Douglas Aircraft Co., Inc.,** Santa Monica, for repair parts.

$97,955—**J. A. Jones Construction Co.,** Atlanta, for demolition and steel piling for static test tower modification at Redstone Arsenal.

$69,633—**Gilfillan Bros., Inc.,** Los Angeles, for repair parts.

$62,886—**Heat Exchangers, Inc.,** Chicago, for testers.

$49,541—**Ampex Corp., Professional Products Div.,** Redwood City, Calif., for tape recorder.

$32,042—**Todd Shipyards Corp.,** New Orleans, for cylinder assemblies.

AIR FORCE

$710,210—**Boeing Airplane Co., Pilotless Aircraft Div.,** for technical data for *Bomarc* components, (13 contracts).

$297,672—**Union Carbide Corp., Linde Co. Div.,** New York, for liquid oxygen.

$200,000—**Harvard College,** for mathematical research and computation.

$197,713—**Northrop Aircraft, Inc., Northrop Div.,** Hawthorne, Calif., for rocket mission evaluators, and data.

$163,062—**Ampex Corp.,** Redwood City, Calif., increase in funds.

$109,506—**Sundstrand Machine Tool Co.,** Rockford, Ill., for transmission assemblies, frequency and load controllers and data for support of the *Snark*.

$104,712—**University of Alaska,** College, Alaska, for studies on the tracking of artificial earth satellites.

$43,000—**Harvard College,** for research toward investigation of solar phenomena.

NAVY

$1,785,234—**Babcock Radio Engineering, Inc.,** Costa Mesa, Calif., for transmitters, test harness and related equipment.

$1,221,486—**Radiophone Co., Inc.,** Monrovia, Calif., for telemetric data recording sets.

$674,725—**Temco Aircraft Corp.,** Dallas, for acquisition and installation of test facilities for the *Corvus*.

$513,935—**DuBrow Development Co.,** Burlington, N.J., for telemetric data receiving sets.

$269,500—**Collins Radio Co.,** Cedar Rapids, Iowa, for communications equipment, handbook and test bench harness.

$254,377—**McKiernan-Terry Corp.,** Harrison, N.J., for launching cylinder sealing strips.

$250,000—**The Gabriel Company, Electronics Division,** Needham Heights, Mass., for omnidirectional UHF drone command antennas.

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letters

Lunik Errors

To the Editor:

In your article *"Lunik* becomes Solar System's Tenth Planet," you have some very important errors that should be corrected. You say "seven and one-half months from now *Lunik* will be somewhere between the orbits of Mars and Jupiter in the asteroid belt," and "at the aphelion of its 15 month orbit it will be 214.75 million miles out from the sun and about 120 million miles from the earth." None of these statements are true. *Lunik* will never go beyond the orbit of Mars into the asteroid belt. According to the latest data on the orbit it will have an aphelion of approximately 122.54 million miles.

Robert Citron and John Porter
Space Flight Committee
Pacific Rocket Society
11950 Allin St.
Culver City, Calif.

To the Editor:

In the article *"Lunik* Becomes Solar System's Tenth 'Planet'," Jan. 12, 1959 issue, the values given for the perihelion and aphelion distances and the period of *Lunik* are not consistent. The given perihelion and aphelion distances of 91.5 and 214.75 million miles represent a semi-major axis of 1.65 au. An application of Kepler's harmonic law gives a period of 770 days for the vehicle, rather than the stated 447 days.

Also, the random usage of "perigee" and "apogee" is disturbing. These as you are aware, apply strictly to geocentric orbits, whereas perihelion and aphelion apply to heliocentric orbits.

Paul E. Koskela
Aeronutronic Systems, Inc.
1234 Airway
Glendale, Calif.

You are both right. An early Tass report of the diameter of Mechta's orbit of 214.75 million miles was misquoted as the aphelion of the man-made asteroid. Deadlines prevented the editors from correcting the error. (See Space Age, Jan. 19, p. 29).

How Many Moons?

To the Editor:

As a subscriber and supporter of your publication, I must take issue with the editorial in your Dec. 15 issue. This is a piece of emotional writing which blithely ignores facts and is guilty of misrepresentation, either by direct statement or through innuendo.

1. The United States has placed three satellites in orbit, not two.

2. The planned program suggested in the editorial is virtually the exact program now being followed.

3. The editorial contradicts itself by stating, in the final paragraph, that there is no one agency through which all projects clear. A previous paragraph states that the National Space Council decides on which space projects shall be attempted, and in what priority . . . There is no gain saying the fact that we have a definite governmental space organization—NSC at the head, with sub-divisions for military (ARPA) and civilian (NASA) projects.

I would like to point out that "space" is not a magic word—merely an extension (with some changes) of the medium through which we've been flying for some 55 years. While control of space by any one nation (if this is possible) is a serious matter, it wouldn't necessarily be a decisive military factor . . .

Leon Cooper
Space Technology
Laboratories, Inc.
Los Angeles

We're both wrong. At the time of writing it was four satellites—Explorer 1, 3, 4 and Vanguard.

Nuclear Rockets

To the Editor:

The Missiles and Rockets report of Soviet nuclear rocket development was very interesting, but credibility would be improved if you could state the sources of your information and obtain further details.

In the same article a minor faux pas occurred when the schematic drawing of the AEC's *Kiwi-A* nuclear rocket showed it firing horizontally, whereas the actual photograph indicates clearly that the Rocketdyne-built nozzle exhauts vertically upward.

In "Propulsion Engineering," on Jan. 5, two errors apparently "crept in." First, the University of Heidelberg would obviously not use a fission reactor as a source of beta particles for its experiments on magnetic focusing of beta particle jets. Second, the estimate of fuel costs for an airborne reactor system of $250-500 million for an initial mass of 35-65 pounds must have assumed a cost per pound of V-235 about 1000 times higher than the official AEC rate.

Despite such occasional slips, m/r has a generally excellent record for being accurate and informative.

W. C. Cooley
20553 Parthemia St.
Canoga Park, Calif.

The schematic of Kiwi-A was prepared some months previously, but we decided to use it anyway even though it was firing horizontally. The University of Heidelberg tells us this is the case, and Russian documents—although perhaps outdated—did give that cost estimate.

Livable Planets

To the Editor:

The article entitled "One Hundred Million Habitable Planets in Universe" by George Rhodes, Special Correspondent in a recent issue was extremely interesting. May I please have further information on the availability of Doctor Calvin's study.

John A. Laansma
Flint, Mich.

The study was undertaken for the Atomic Energy Commission.

Optical Guidance

To the Editor:

Raymond M. Nolan in his "Astrionics" column in the Dec. 29 issue mentions speaker reference to optical line-of-sight guidance to parallel inertial guidance in space travel.

Could you please supply me with the name of the speaker, title and date of the speech, and the proper contact to write to for a copy of this paper? Perhaps you could supply me with a copy?

George Lawrence
Scientific Apparatus Makers Assn.
Washington, D.C.

Copies of the speech available from Parks Air College, St. Louis University, E. St. Louis, Ill.

Regulus II Facts

To the Editor:

Regarding your Washington Countdown in the Jan. 12 issue, Mach 2 *Regulus II* not only is America's only supersonic airbreather, but with altitude operating capabilities in excess of 60,000 feet it far exceeds *Mace* in altitude as well as speed.

John J. Johnson
Chance Vought Aircraft, Inc.

A double check of the services resulted in a statement by Navy spokesmen that Regulus II has an operating altitude of 60,000 feet, while Air Force officials gave no precise figure but said Mace's operating altitude is in excess of 35,000 feet.

Operations Research

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Those who have professional questions or desire additional information are invited to write Dr. William Karush, Head of the System Development Corporation Operations Research Group at 2414 Colorado Avenue, Santa Monica, California.

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"Method for First-Stage Evaluation of Complex Man-Machine Systems"

A paper by I. M. Garfunkel and John E. Walsh of SDC's Operations Research Group is available upon request. Address inquiries to Dr. William Karush at System Development Corporation.

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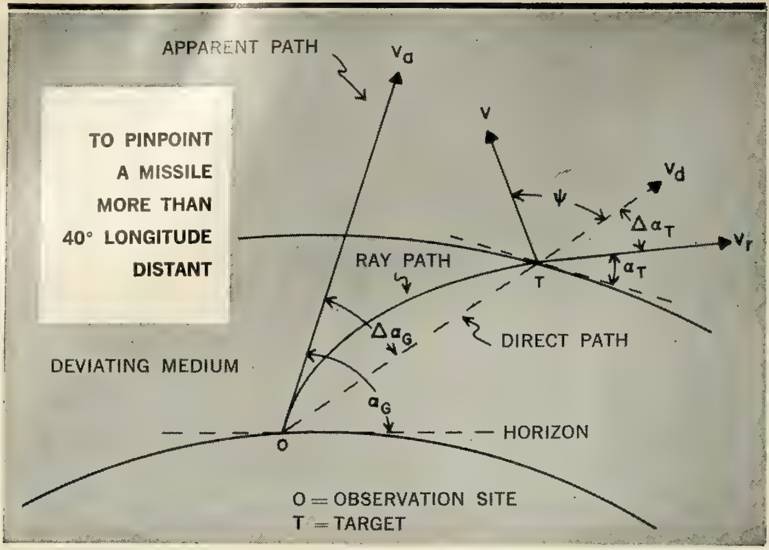

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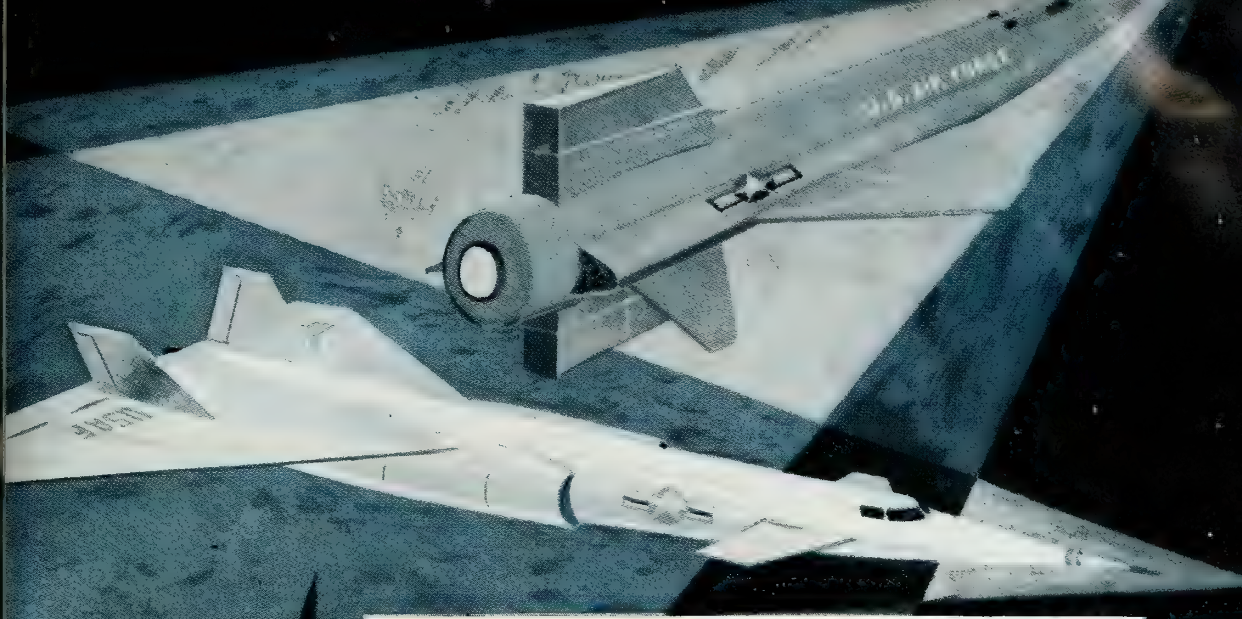

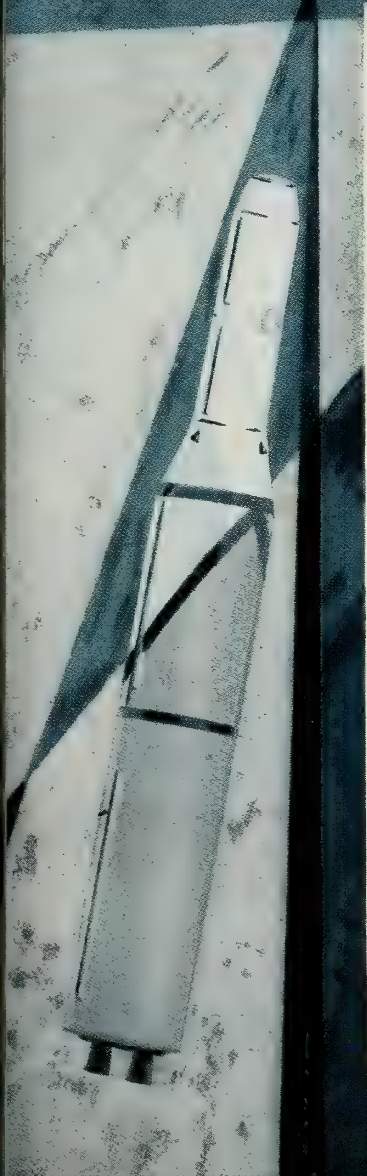

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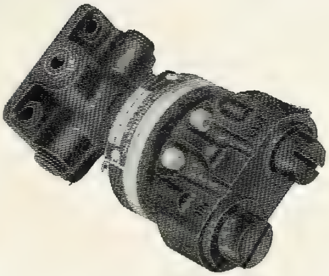

High performance hydraulic pumps by Eastern are uniquely suited to the exacting operating requirements demanded in the craft of tomorrow.

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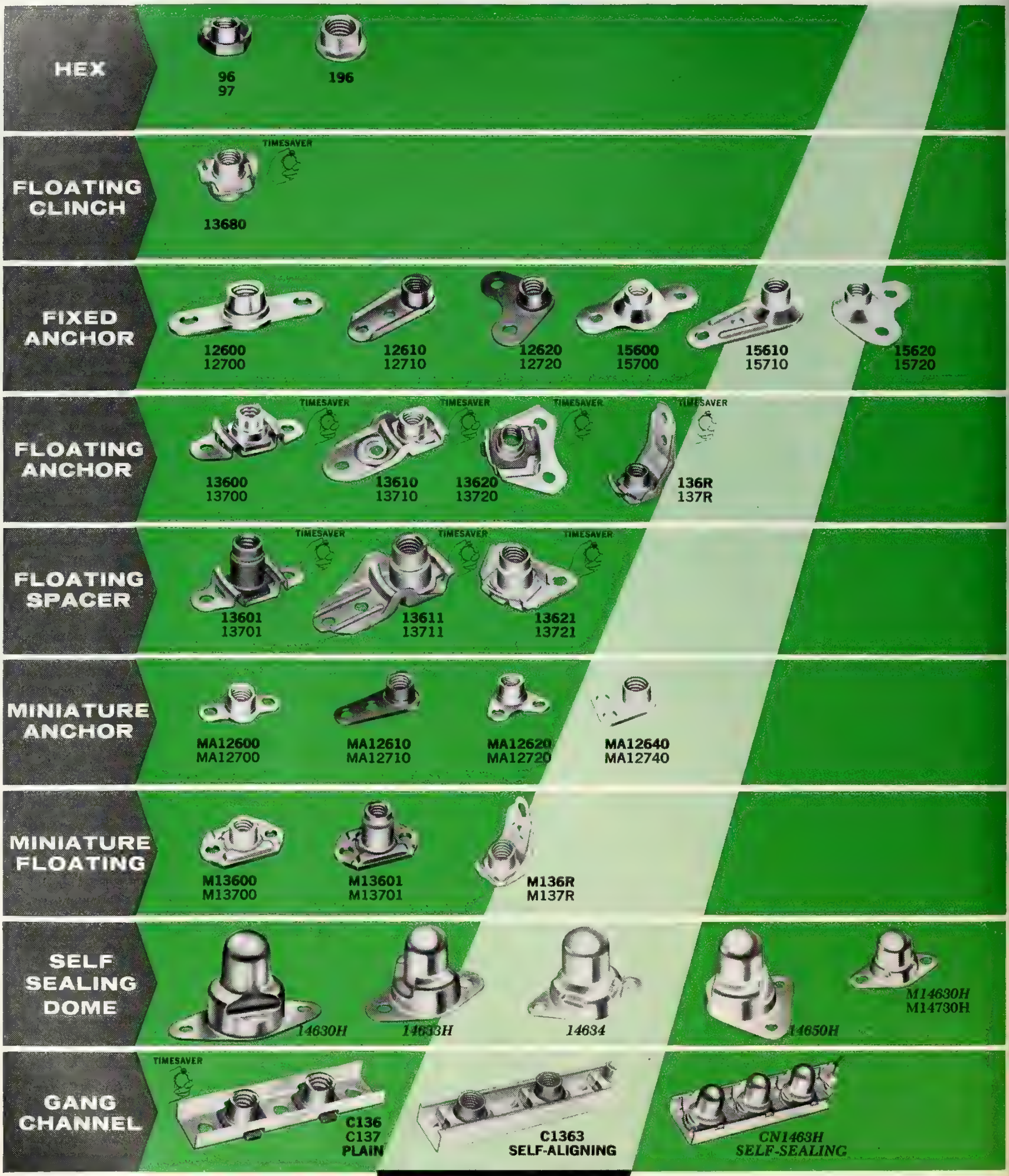
This chart shows the most used NAS standard and special, low-height, lightweight, self-locking nuts. All meet Specification MIL-N-25027(ASG). Series numbers of the alloy steel, 550° F. nuts are shown in bold face type; series numbers of the CRES, non-magnetic, 900° F. nuts, are shown in light face type.



HEX	**96** 97	**196**				
FLOATING CLINCH	**13680**					
FIXED ANCHOR	**12600** 12700	**12610** 12710	**12620** 12720	**15600** 15700	**15610** 15710	**15620** 15720
FLOATING ANCHOR	**13600** 13700	**13610** 13710	**13620** 13720	**136R** 137R		
FLOATING SPACER	**13601** 13701	**13611** 13711	**13621** 13721			
MINIATURE ANCHOR	**MA12600** MA12700	**MA12610** MA12710	**MA12620** MA12720	**MA12640** MA12740		
MINIATURE FLOATING	**M13600** M13700	**M13601** M13701	**M136R** M137R			
SELF SEALING DOME	*14630H*	*14633H*	*14634*	*14650H*	*M14630H* *M14730H*	
GANG CHANNEL	**C136** C137 PLAIN	**C1363** SELF-ALIGNING	*CN1463H* *SELF-SEALING*			

Detailed information on all nuts shown here is contained in Nutt-Shel's LIGHTWEIGHT NUTS brochure.
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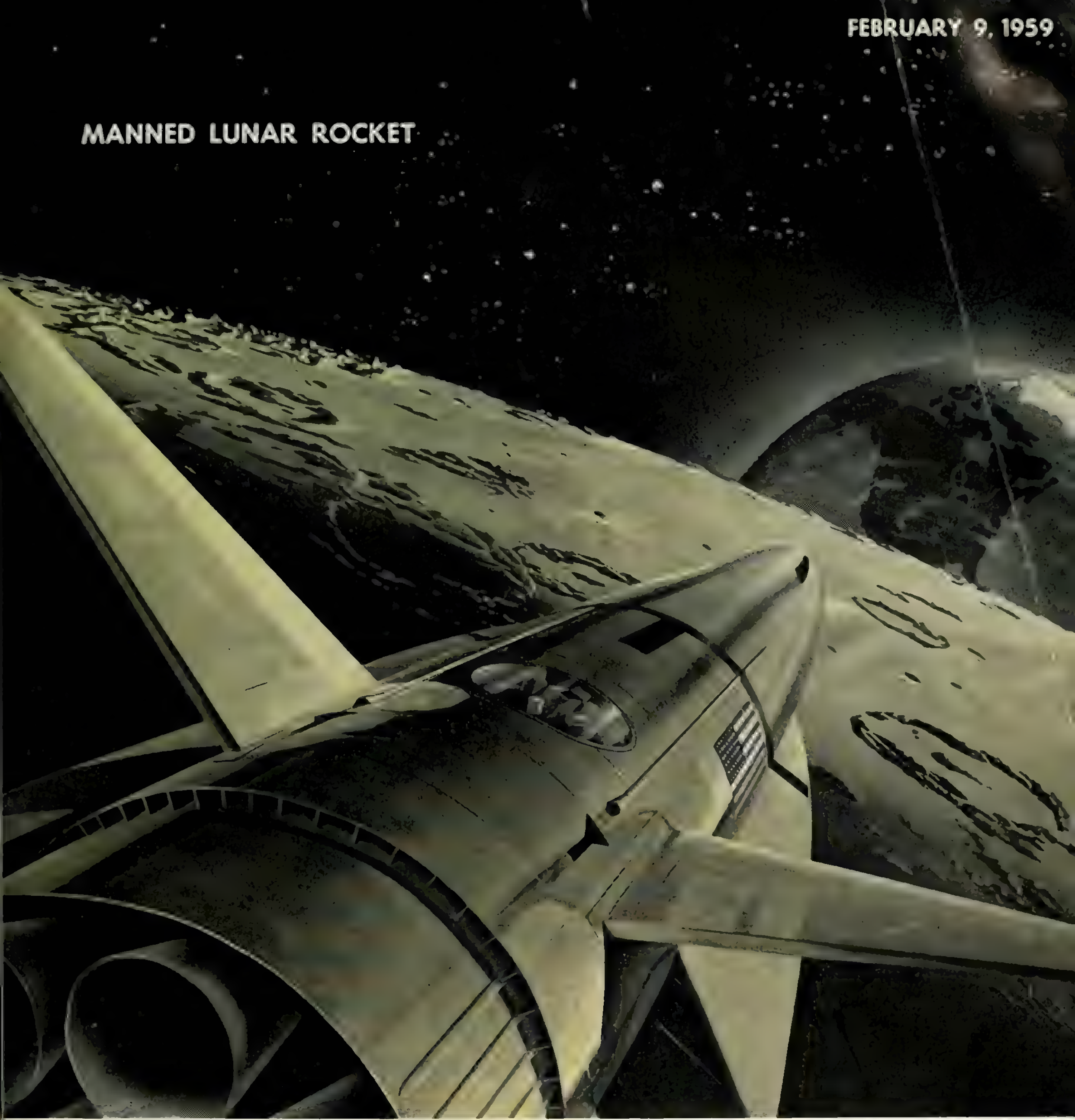

missiles and rockets

MAGAZINE OF WORLD ASTRONAUTICS

Annual

ELECTRONICS AND GUIDANCE ISSUE

AN AMERICAN AVIATION PUBLICATION

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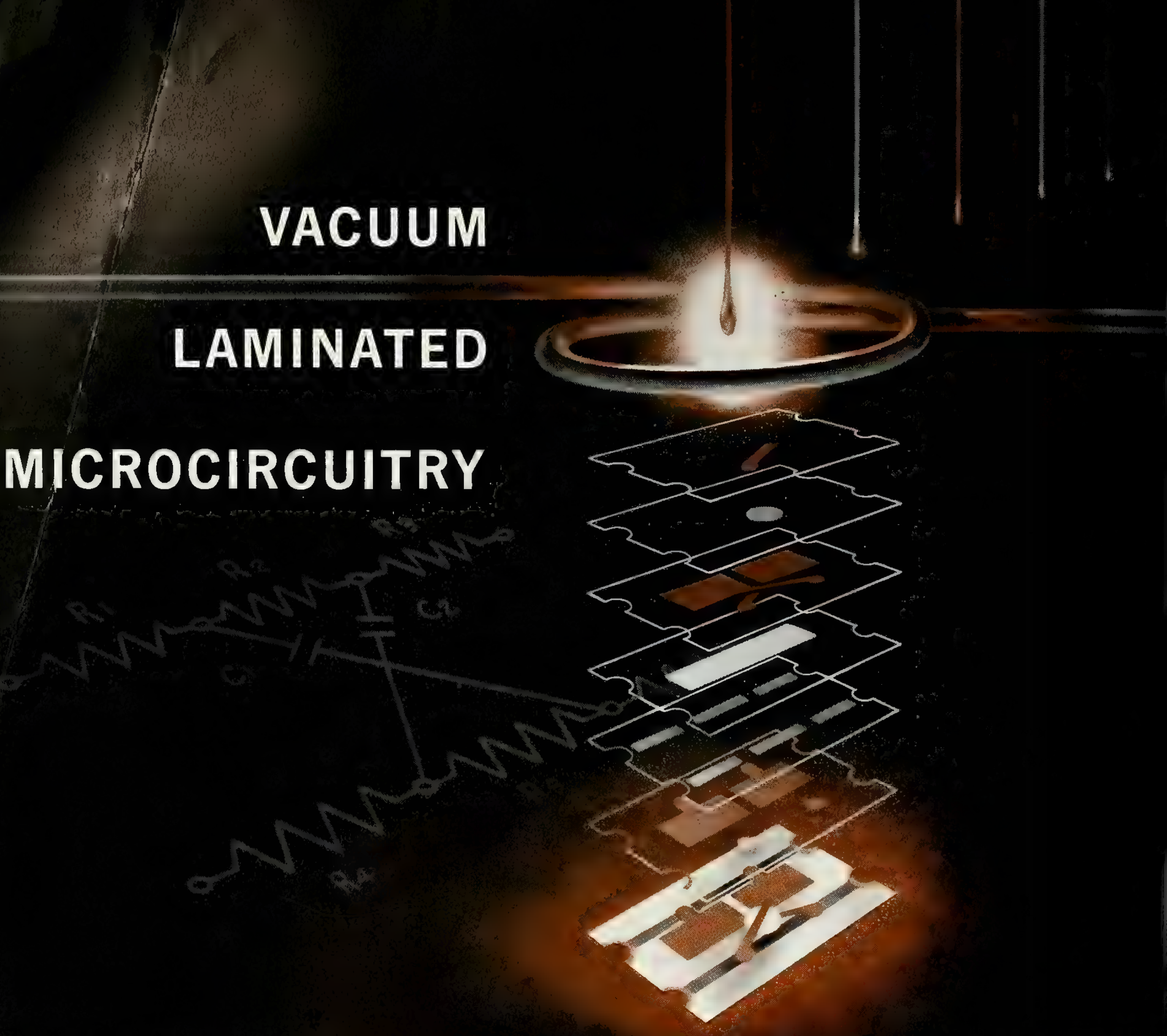

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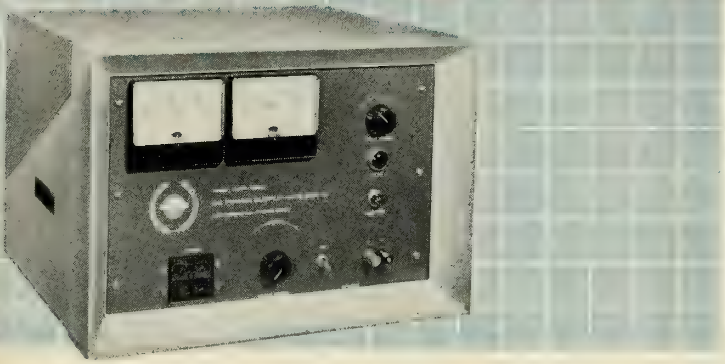

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MTR28 30	24-32	30
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missiles and rockets Vol. 5, No. 6, Feb. 9, 1959

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missiles and rockets

MAGAZINE OF WORLD ASTRONAUTICS

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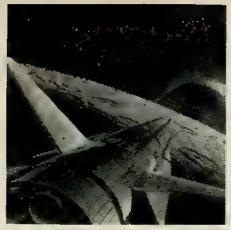
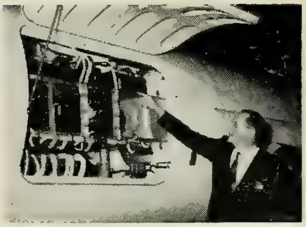
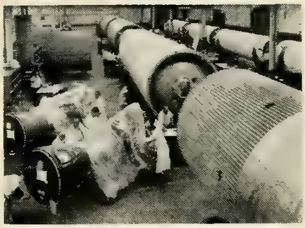


COVER: Nortronics conception of manned spacecraft circling the moon.



GUIDANCE for *Thor* pointed out by A-C Spark Plug's Dr. James C. Bell at Douglas plant tour.

EIA'S President David Hull talks frankly on future of electronics.



CHRYSLER showed *Jupiter* assembly line last week. *Redstone* line is in background.

INTERNAL *Thor* model is demonstrated by Donald Douglas, Jr., and AF Lt. Col. Greene at press meeting.

Bendix* has long been a leader in supplying controls and fuel systems for all types of aircraft engines. Today, Bendix is proving to be a natural for new challenges in related missile fields—on ram jets, rockets, nuclear power, and other advanced propulsion systems. So, when it comes to controls, remember that Bendix has the background—and is anxious to share it in solving your problems. *REG. U.S. PAT. OFF.

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The Age of the Electron

As we experience the first thrills of space exploration and receive new information about the Universe surrounding us, we become conscious of new problems and of new potential solutions that underline the ever-increasing penetration of electronics into all phases of our daily lives, of our industrial endeavors and of our scientific research.

We might trace the range of activities of radio engineers since the establishment of the Institute of Radio Engineers in 1912. Marconi had established radio communication across the Atlantic and even to Hawaii using wavelengths of 1000 to 10,000 meters; but it was evident that shorter waves would lead to much higher radiation efficiencies.

The invention of the electron tube and its perfection by engineers who understood the flow of free electrons in vacuum under the effect of controlling electrodes led to large power generation at medium wavelengths. This made radio available for public entertainment as well as for air navigation and control.

The new classes of klystrons, magnetrons, and, finally, traveling wave tubes constitute ingenious exploitations of the interactions between electrons and electromagnetic fields where the electron inertia as a particle characteristic plays an important role.

In the meantime, the knowledge gained by the study of crystal structure and its application to semiconductors . . . has led to the new field of so-called solid state devices, the equivalent of certain types of electron tubes. The transistor is the most appealing commercial end product since it will permit miniaturization of many electronic circuits and systems for applications where either space or weight or both become critical factors. The instrumentation in satellites can be made not only light but much more reliable because of the rugged characteristics of these tiny wafers of semi-metals.

We are also returning to the study of discharge phenomena, which were first explored about 100 years ago. This time we call the ionized gases plasma and are interested in their properties, in propagation of signals through them, and in aerodynamic motion of bodies through them.

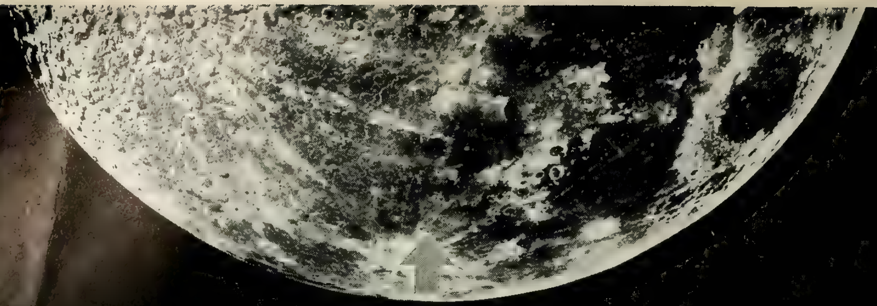
As early as 1902, O. Heaviside in England and H. E. Kennelly at Harvard University had independently put forth the hypothesis that the earth was surrounded by an ionized layer which reflects the long radio waves, the only ones with which experience had been established at that time. Today we have penetrated this ionosphere and have, indeed, preliminary information from much greater distances indicating other layers of intense radiation.

Additional interest in plasma physics is linked to the possibility of controlled nuclear fusion. Approaches to this potentially vitally important subject include studies of plasma generation, control by magnetic fields, acceleration by electric fields, and creation of exceedingly high temperatures so as to approach the state of total ionization which appears to be characteristic of the sun's atmosphere. This new field is designated as magneto-hydrodynamics and is also linked to endeavors to produce ion propulsion which might be of significance for space vehicles in the highly rarified strata of outer space.

We are, indeed, approaching rapidly the age of the electron, utilizing its swarming drift in conductors to signify electric power for useful work, for the control of processes, for the generation of heat; employing electron beams in vacuum to produce and amplify oscillations up to the highest imaginable frequencies for the transmittal of intelligence, for the reception of information, for service in entertainment; exploiting various levels of local ionization in solids not only for similar purposes but also for high speed computation; and now attempting to force submission to our control of completely ionized matter, whatever its original state might be.

In all of these endeavors we are dealing with the inanimate elements and can be sure of their performance once we have deciphered the laws governing their action. We are yet far, far from similar capabilities with the living aggregates; we know that there, too, ionization and electron transitions are important but we have very little knowledge that would permit control.

DR. ERNST WEBER
President, Polytechnic Institute of Brooklyn;
President, Institute of Radio Engineers



solving critical control problems for space-age progress

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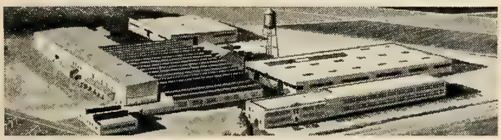
NAVY SELECTS RYAN C-W DOPPLER NAVIGATORS FOR MAJOR AIRCRAFT

Six major types of Navy aircraft will be equipped with Ryan continuous-wave Doppler navigation systems, the AN/APN-122 (V), under an initial $20-million contract awarded by the Navy to Ryan's Electronics Division. Ryan's automatic, all-weather, self-contained navigators will be installed in the Navy's Lockheed Neptunes (P2V), Martin Marlin patrol planes (P5M), carrier-based Douglas Sky Warriors (A3D), and three types of Grumman aircraft.

Developed in cooperation with the Navy, these advanced electronic systems are the lightest, simplest, most compact, and most reliable of their type. The new order, one of the largest of its kind, emphasizes Ryan's leadership in navigation and guidance systems.

With a solid backlog of this and other important contracts for RYANAV systems, the Ryan Electronics Division is growing even faster than this fastest growing industry. Personnel and facilities are being doubled, both in the new production plant at Torrance, Calif. and at the San Diego facility, where a modern new electronics research center is under construction.


New electronics production facility at Torrance (near Los Angeles).

New electronics research center at San Diego.

Ryan's rapid growth in electronics is creating new opportunities for engineers and technicians

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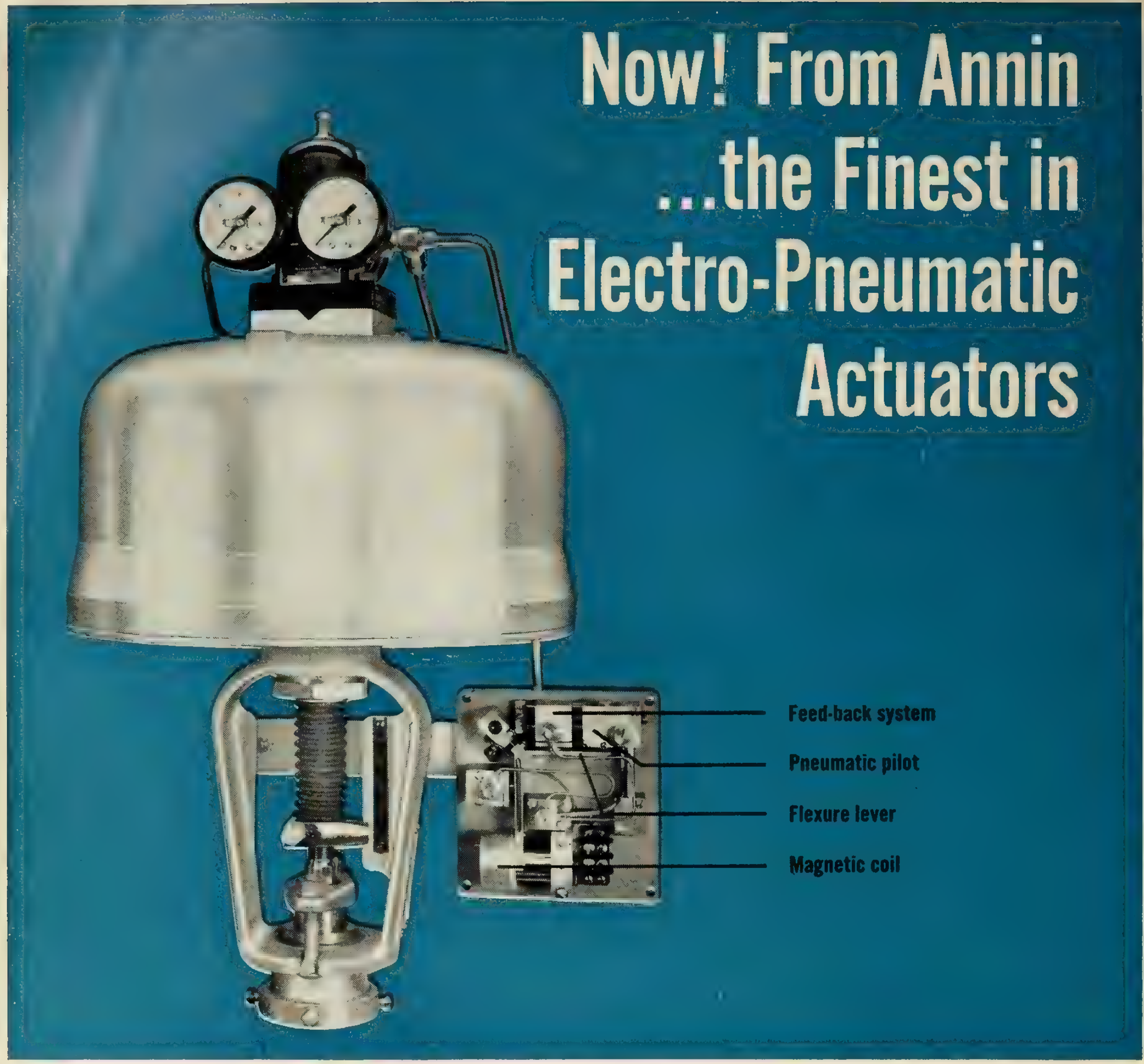

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The Model 30,000 has been developed to provide process engineers with a practical transducing element for converting a small electrical signal to an accurate and stable pneumatic output pressure. It embodies only four basic sub-assemblies, which minimize motion and wear, simplify adjustment and installation. The Model 30,000 features full-scale zero adjustment and a wide range of span settings for split range and sequencing applications. Absence of complex components, together with minimum installation, contribute to low maintenance. Linearity and accuracy reach a new high in electro-pneumatic transducing with the Model 30,000. *Technical data on request*

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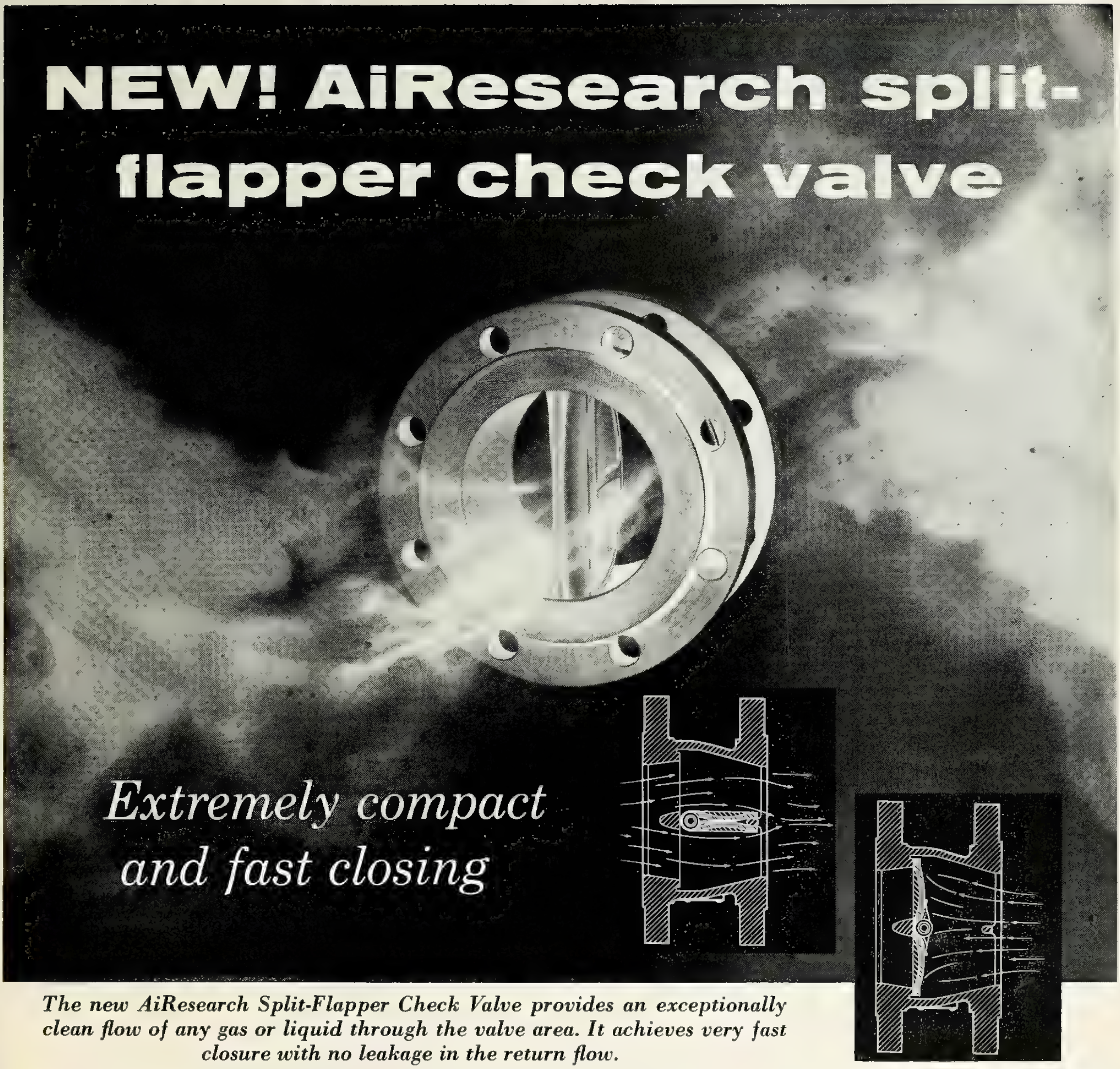
NEW! AiResearch split-flapper check valve



The new AiResearch Split-Flapper Check Valve provides an exceptionally clean flow of any gas or liquid through the valve area. It achieves very fast closure with no leakage in the return flow.

This extremely compact, lightweight unit has important applications in petroleum, chemicals, paint, food processing, missile fuels . . . any industry with a gas or liquid flow problem. The valve can be made from various materials, covering an operational temperature range from cryogenic levels to 1700° F.

The AiResearch Split-Flapper Check Valve pictured above is made of aluminum...rugged and dependable with only two moving parts. Twin forged flappers, opening in the direction of normal flow, are supported through the center of the piping. In the event of backward flow, their spring mounting and aerodynamic design assure fast closure of the valve.

Insertion of short flapper plates through the bore eliminates exterior bonnet and gasket joint and reduces length. Other structural advantages are better support of the plates, greatly reduced shock loads on the hinges and sealing surfaces, reduced springload, less mass and material to be heated or cooled by the flow element.

Ideal for portable as well as stationary applications, the new AiResearch Split-Flapper Check Valve can accommodate lines 1 to 12 inches in diameter. AiResearch has 17 years of experience in the production of valves and controls.

Your inquiries are invited.

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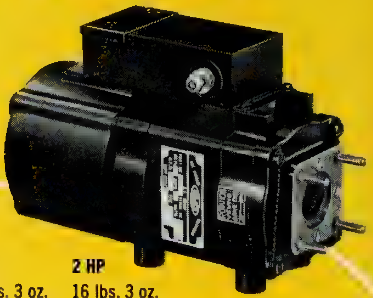
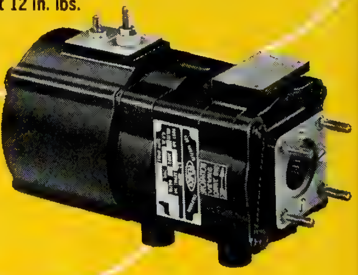
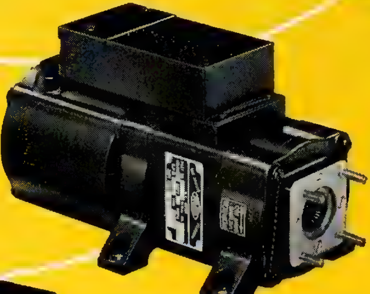


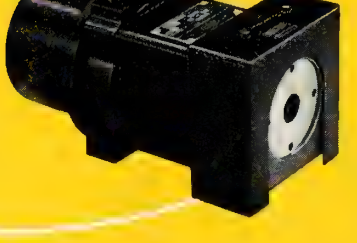
Type D-1082	**4 HP**	**2 HP**
Weight:	16 lbs. 3 oz.	16 lbs. 3 oz.
Motor Torque:	25 in. lbs.	12 in. lbs.
R.P.M.:	10,000	10,700 (approx.)
Terminal Voltage:	27 volts DC	27 volts DC
Operation:	In a period of 34 minutes: any 4 min. @ 25 in. lbs., balance at 12 in. lbs.	



Type D-1082-1	**4 HP**	**2 HP**
Weight:	13.87 lbs.	13.87 lbs.
Motor Torque:	25 in. lbs.	25 in. lbs.
R.P.M.:	10,000	11,500
Terminal Voltage:	27 volts DC	27 volts DC
Operation:	2 minutes max. @ 25 in. lbs. plus 10 min. max. @ 12 in. lbs.	



Type D-1029-1	
Weight:	20 lbs.
Horsepower:	6 HP
R.P.M.:	7500
Terminal Voltage:	26.6 volts DC
Duty Cycle:	4.5 HP for 7.5 minutes 6.0 HP for 20 seconds 2.0 HP for 30 minutes



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the missile week

washington countdown

Conflicting reports . . . on U.S./USSR ballistic missile strength keep coming from Defense Secretary McElroy. Item: McElroy told reporters there would be only "one or two missiles" difference in U.S. and Russian stocks of war-ready ICBM's by the year's end. Item: He and Gen. Nathan F. Twining reportedly told the Senate Foreign Relations Committee behind closed doors this:

By 1962 . . . Russian strength (with U.S. numbers in parentheses) will be: ICBM's 1,000 (300); IRBM's 2,000 (135); bombers, 1,200 (1,750); Navy bombers, unknown (500); IRBM submarine-launched missiles, unknown (100).

By January, 1960 . . . Twining and McElroy told the Committee, Russians will outnumber US in ICBM's 300 to 10; and will have 750 IRBM's to our 75.

More money for research . . . was the plea made before Congress last week by Lt. Gen. Samuel E. Anderson, ARDC chief, who said $534 million had been chopped from his budget by the Administration. Anderson claimed it is needed in the vital areas of basic and applied research.

10 to 15 years . . . is NASA Deputy Administrator Dr. Hugh L. Dryden's estimate of how long it will take the United States to put a man on the moon. Members of the House Space Committee were surprised, since the summary of expert opinion in a recent Committee report indicated that this was possible within a decade. Rep. James G. Fulton (R-Pa.) replied that if it takes as long as Dryden thinks, "there'll be a man there saying 'nyet' when he arrives."

***Regulus II* termination . . .** was not just an economy move, according to Congressional testimony by Adm. Arleigh A. Burke. Rapid progress on *Polaris* was another reason. Answers came as Senators asked why cancellation after $290 million had been spent and there had been 23 successful flights. Was it prudent to cancel? In answer, the CNO said, "That's a good question, but it was prudent."

Further testimony . . . revealed what was termed "some minor sacrifice in range" of the first *Polaris* missiles. What was not explained was that this applies only to test vehicles and that *Polaris* missiles deployed to submarines in 1960 will have the designed range of 1500 miles. These operational missiles are designated A1-P. They will follow the current AX series and an A1-X series which will incorporate the guidance system. First full-scale test shots of the A1-P will be early in 1960.

***Polaris* follow-on . . .** program has not been announced but a number of possibilities are being considered. Navy said range could be doubled by lengthening the missile by 30 inches. Allegany Ballistics Laboratory is working on a double base propellant, while another area getting attention is an improved control system to eliminate gimballing.

What's cooking? . . . in the space kitchen was one question Senate Democratic leader Lyndon Johnson tried to get answered by ARPA and NASA officials appearing before his space committee. Later, after trying for an hour to get a clear definition of duties and responsibilities, he said: "What I want to know is, who is chief cook in the space kitchen?" The question was tossed to Roy Johnson, Dr. Herbert F. York and DOD Missile Chief William M. Holaday. The collective answer—"Dwight D. Eisenhower."

Failure of *Discoverer* firing . . . at Vandenberg is being laid to premature firing of the second-stage engine which permitted acid to foul the entire launch vehicle. Because Mikoyan was in country, crew was under severe high-level pressure not to fire and fail—thus jittery. More recent *Titan* firing at Canaveral was scrubbed when go-no-go black box cut off engine in late stages of countdown.

Reliable information . . . indicates that the Russians do what they say they do, NASA's T. Keith Glennan told Congress last week, and there is no reason to doubt their claims about *Lunik* or any other scientific advance.

When men push off for Space, they will need the absolute accuracy of inertial and stellar-inertial guidance systems to navigate in the trackless void. Working with the Air Force, Autonetics has spent twelve years bringing both to their present high state of development. Autonetics made America's first successful flight test of an inertial guidance system in 1950. One of the few companies in the world today with full capability to design and quantity manufacture inertial navigation systems. Autonetics offers exceptional opportunities to qualified engineers. Write A. H. Benning, Manager, Employment Services, 9150 East Imperial Highway, Downey, California.

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industry countdown

Radar beacons for *Titan* . . . will be produced by ACF Industries, Avion Division, under latest contract for $200,000. Beacons are used to complement the ground radar during test flights of the ICBM and tracking of the nose cones.

Proposed merger . . . of Sylvania Electric Products, Inc. into General Telephone Corp. will become effective about March 5, provided shareholders approve the plan at a Feb. 11 meeting.

Boeing is building . . . an arc-discharge type tunnel that will test models at approximately 18,000 mph. Expected to be used in the *Dyna-Soar* program, test section of the tunnel will have a 40 inch diameter model positioning area. Tunnel—the eighth at Boeing—will be in operation by the end of the year.

***Discoverer* second stage skin . . .** is made of a new high strength-to-weight ratio magnesium alloy by Dow Chemical. Three thin-wall tanks for the propulsion system are fabricated to a tolerance of ± .002 inch. Magnesium was selected for the *Discoverer* upper stage for combatting the expected high aerodynamic heating, wide temperature variation when the vehicle passes in and out of the earth's shadow, and for resistance of compressive buckling.

Explosive forming . . . is still an art and not a science, warns the Propellex Chemical Div. of Chromalloy. Yet, this revolutionary forming method, under investigation by many companies, is expected to have widespread application in the missile industry. One "apparently" outstanding advantage of the explosive forming technique is the induced plasticity resulting in a 30% increase in material strength. Secret of the technique is the geometry of the explosive charge.

***Eagle* guidance system . . .** consisting of an airborne radar, digital computer, and operator displays, is being sub-contracted by Bendix Aviation Corp. Sanders Associates, Inc., credited with development work on guidance systems for *Sparrow*, *Terrier* and *Hawk* systems, will design and develop part of the *Eagle's* command system.

Last *Regulus I* . . . Number 514 in a line dating back to 1950, has been delivered from the Dallas plant of Chance Vought Aircraft to Pt. Mugu. Navy made 850 flights during the missile's test program—some as many as 18 flights before destruction.

Chance Vought wins . . . contract to develop a system of standards in the fields of quality control and reliability for the *Polaris* after a competitive study by Bureau of Ordnance at numerous major aircraft firms. C-V will publish standards outlining the minimum quality control and reliability system requirements for each of the contractors on the *Polaris* program.

***Thor* weapon system . . .** Contractor Technical Compliance Inspection (CTCI) is underway at Douglas Aircraft Company's Sacramento facility. It is the first such inspection to be performed on a ballistic missile.

***Hound Dog* and *Quail* . . .** facilities construction at 11 U.S. and one Puerto Rican air base is expected to cost approximately $9 million—appropriations to be made during the current fiscal year. Bases and costs are: Eglin AFB, $650,000; Loring AFB, $1 million; Dow AFB, $800,000; Griffiss AFB, $800,000; Seymour-Johnson AFB, $650,000; Blytheville AFB, $650,000; WPAFB, $800,000; Robbins AFB, $700,000; Wurtsmith AFB, $800,000; Altus AFB, $750,000; Minot AFB, $800,000 and Ramey AFB, Puerto Rico, $550,000.

Instrument planning contract . . . for PMR has gone to Aeronutronics Systems, Inc., a subsidiary of Ford Motor Co. Runner-up for the six month study was a team led by the Canoga Division of Underwood Typewriter. Others associated with Aeronutronics are Cook Research Labs, Dunlap Associates, Eastman Kodak, and Page Communication Engineers.

No *Snark* cancellation . . . or interruption of production is contemplated AF says. Secretary McElroy indicated in testimony before Congress that the Northrop program would be cancelled. Present contract for $114.5 million reportedly would carry production through 1960.

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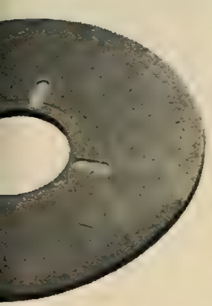

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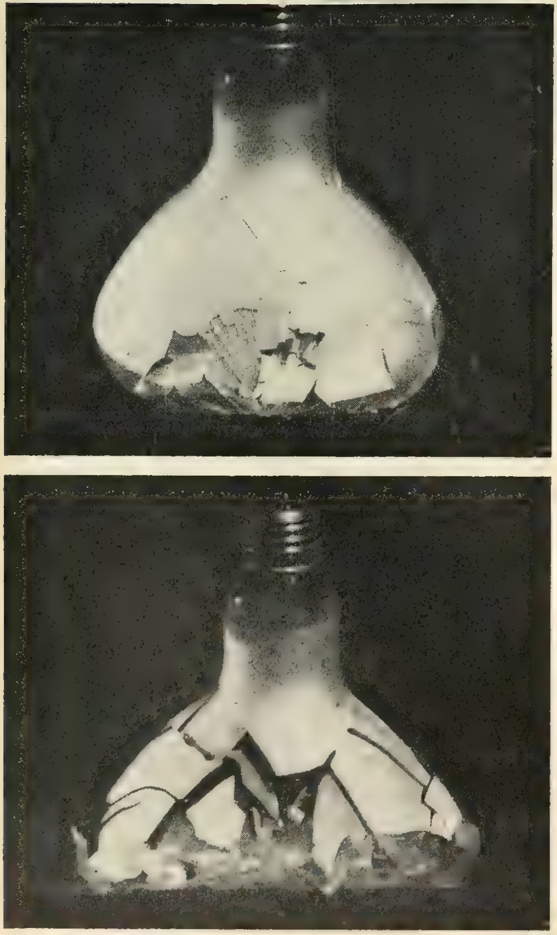

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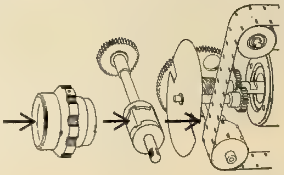

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missiles and rockets

MAGAZINE OF WORLD ASTRONAUTICS

DOD Chiefs Back Budget; Regret Cuts

Sentiment heavy in Congress for restoring many budgetary cuts. ARPA's Johnson says both his agency and NASA need $300 million additional.

ARDC had $534 million cut from its request. Senator Anderson wants more development funds for nuclear aircraft. Missile strength figures debated.

WASHINGTON—A seven-billion-dollar question faces Congress as it goes into the second month of its new session.

Chiefs of the Army, Navy and Air Force, testified before the Senate Preparedness Investigating Subcommittee that individual budgets submitted by them to the Secretary of Defense were cut a total of $7.1 billion. Under oath, they said the $40.9 billion budget submitted by the Administration was adequate. But each expressed reservations in regard to his own service.

Questioning by members of the Subcommittee headed by Senate Democratic Leader Lyndon Johnson (Tex.) generally followed party lines. The Democratic majority, spearheaded by Johnson and Sen. Stuart Symington (Mo.), drew from the witnesses their reluctant approval of the overall budget. Republican minority members obtained statements substantiating the claim that the overall budget is sufficient.

• **ICBM lead**—First to appear was Secretary of Defense Neil H. McElroy, flanked by Chirman of the Joint Chiefs of Staff Gen. Nathan E. Twining. McElroy, in line with earlier statements, said this country did not intend to attempt to match Russia missile for missile in the ICBM field, but the total deterrent forces—bombers, missile-launching submarines, foreign-based IRBM's, and forthcoming ICBM's—are adequate, and there are no serious gaps in the national defense for the time covered by the budget submitted.

Symington asked the defense chief how it could be that less money was being asked now than was sought last year, yet it had been stated there was an emphasis on missiles? McElroy said that this was true because obsolete items had been eliminated, items which have been completed or are nearing the end of development and test stage would require less money, and spending generally would be more efficient.

• **JCOS**—Appearing before the subcommittee in the afternoon were the uniformed service chiefs.

Chief of Naval Operations Adm. Arleigh A. Burke testified that his budget board originally submitted to him a request for $17-18 billion dollars. This was pared to $14 billion, which was the budget sent to the Department of Defense. Final budget figure for the Navy was $11.5 billion.

Gen. Thomas D. White, Chief of Staff of the Air Force, said that a request for $20.6 billion was reduced to $18.6 in the final budget.

Gen. Maxwell D. Taylor, Army Chief of Staff, said his budget planners handed him a proposed $13.6 billion budget which he cut to $12.5 billion before sending it to DOD where it was finalized at $9.9 billion.

Gen. Randolph McC. Pate, Commandant of the Marine Corps, whose budget is covered by the Navy's, was the only service chief to say he was satisfied with the weapons he has and is getting. However, he said that while he did not argue with the cut, personally he would have done it in another way.

• **Reservations**—Sharp questioning from Democratic Senators brought out the specific reservations of the military chiefs.

Modernization of the Fleet was Burke's major concern. This, he said, should have been begun 15 years ago. He testified that the present budget provides for modernization of about 2% of the Fleet, of which 81% is wearing out or approaching obsolescence.

The reduction in requested funds, according to Burke, resulted in the termination of the *Regulus II* program which he said "still is the best air-breathing missile we have." The Rocket Assisted Torpedo *(RAT)* also was a casualty but will be replaced with forthcoming more efficient weapons. Overall missile procurement will be reduced as a result of the cut, he said.

Pate admitted the cut in Navy funds will mean a reduction in landing teams.

White said his principal reservations concerning the AF budget dealt with financial ability to replace B-47's with B-52's and B-58's. The B-58 recently was used in test firing of an air-launched ballistic missile. White also regretted lack of acceleration of the nuclear-powered aircraft. It failed to get priority, he explained, because the scientific community says it is not completely feasible at this time. His other reservations dealt with such matters as personnel problems and housing.

Sen. Clinton P. Anderson (D-N.M.), newly-elected Chairman of the Joint

Atlas Production

FIRST production line photograph of *Atlas* ICBM at Convair shows vehicles to be fired in the test program and similar missiles for operational use.

Congressional Atomic Committee, said he will push for an additional $280 million to step up development of nuclear and atomic-powered planes. With this money, it could be done in four years, he said.

• No padding—All the service chiefs declared their higher budgets had not been padded in any way and represented actual needs of their forces. Taylor was the only witness to say in so many words that his budget "is not adequate within the confines of the Army."

Taylor, like Burke, was worried about modernization, which he said would not be permissible under the present budget. He said he had submitted a reasonable program for development of the battlefield mobility concept and modern weapons, but that the $9.9 billion budget will do little more than provide for replacement of equipment wearing out.

Taylor further stated he had great reservations in the effect the reduced budget might have on the *Nike-Zeus* program and on other Army surface-to-air missiles.

Chairman Johnson throughout the questioning urged witnesses to give their personal and honest opinions as to adequacy of the budget. All insisted that the memorandum recently sent to Secretary McElroy by Budget Director Maurice Stans had nothing to do with their approval of the overall budget. However, each followed the provisions of the memorandum and pointed out that the budget had been determined from the overall viewpoint and that they were not asking for more money.

Johnson's viewpoint was apparent from his repeated urging that they say exactly what they thought as experts and as those responsible for the nation's defense. He summed it up by saying:

"It is beyond me how your three inadequacies can make a single adequacy."

Later, he told Taylor:

"By approval with reservation you really mean the Secretary of Defense makes the decision whether a defense program is adequate and you all agree not to fight it, isn't that what you mean?"

"We offer our superiors our best advice and he makes the decision," Taylor replied.

Johnson later said the military chiefs had testified "like good soldiers."

• Retaliation—Another witness, Maj. Gen. Bernard Schriever, head of AF Ballistic Missiles Division, said production of ICBM's should be stepped up, although the *Atlas* program is on schedule as set up in 1955.

"In this ballistic missile age, we should do everything we can to reduce the risk to our retaliatory capability and more ICBM's will do this," he said. "And we certainly can build more if we want to put the weight behind it."

Gen. Thomas S. Power, head of the Strategic Air Command, which McElroy described as the nation's main retaliatory force, told the Senators there is no airborne alert in this country though he was ready to put one up any time he was told to do so. He said SAC presently is planning wider dispersal, tightening its precautions against sabotage, hardening bases and trying to improve communications to insure retaliatory capability after an enemy attack. He admitted that while the warning system against manned aircraft is good there is no warning system against missile attack.

Number one priority at SAC, he said, is the B-52G bomber-*Hound Dog* missile, and the KC135 tanker package to extend SAC's range.

• ARPA—DOD's Advanced Research Projects Agency got a thorough going-over. Witnesses appearing, following a morning session with National Aeronautics and Space Administration officials, included Roy Johnson, ARPA director; William Holaday, Director of Guided Missiles; Dr. Herbert York, newly-appointed Director of Defense Research and Engineering; and Dr. Wernher von Braun, of the Army Ballistic Missiles Agency.

Johnson was the only witness to say specifically how much more money he needed, though von Braun told the Senators more money is needed especially in research and to buy vehicles for test purposes.

Commenting that "I may be out of a job," Johnson said ARPA needs a supplemental appropriation of $40 million for the clustered 1.5-million-pound-thrust vehicle. Including this, Johnson estimated that the space program would require for ARPA and NASA an additional $150 million in fiscal 1959 and a similar amount in 1960. This money would be utilized in stepping up the booster program, development of better tracking and high-energy upper stages.

Von Braun told the subcommittee this country is five years behind the Russians in rocketry. He said the gap could be closed in a year if the Reds stood still, but there was no sign they would do that.

More money is needed, he said, not for greater numbers of missiles but for research and for test vehicles in early phases. He predicted this would speed the time when space vehicles can be produced with twice the thrust of present Russian hardware.

• Disagreement—ARPA's Johnson and NASA Director T. Keith Glennan, Jr., disagreed as to whether or not President Eisenhower is willing to spend enough money for space research and technology in fiscal 1960.

'No," was Johnson's answer after two hours of questioning before the Senate space inquiry.

"Yes," was the cautious answer given by Glennan, who qualified this by saying that his agency would ask for more money in the near future if it were needed.

The best estimate is that ARPA and NASA will get the $300 million Johnson is asking for. Whether the Administration will freeze the funds is another matter.

Glennan's testimony contradicted Johnson's.

In answer to a question by Sen. John C. Stennis (D-Miss.), Glennan said that NASA had enough money at the "present stage of our development," but that "this field is going to move . . . fast, and if we need more money, we will be back."

The NASA Administrator modified this statement slightly in an appearance before the House Space Committee by saying that he doubted whether more money would speed the program, though it might provide greater assurance of meeting goals.

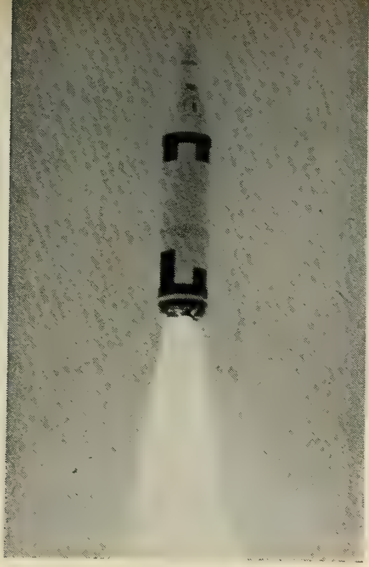
• Red lead denied—Glennan admitted that Russia was 18 months to two years ahead of us in rocket power, that their guidance was apparently better and that the Russians might put a man in space this year—thus beating us by two years.

He denied that Russia had the allover space lead.

The nation is being "deluded," according to Glennan, into thinking that the space program should be pinned to the development of high-powered rocket boosters.

The important thing, Glennan stated, is how much information "we get back out of space." He said there is no sign of any great difference between the information received by the scientists of either nation. In fact, Glennan reported, the quality of the Russian information received from space might be less than our own in some instances.

The House Space Committee criticized Glennan for taking a "penny-pinching" approach to the international space race on the one hand, and calling for Americans to "roll up our sleeves" and get on with the job or "spend our money buying telescopes" to watch Russians space advances on the other.



Complication for Solids: Thrust-Direction Control

Ballistic missiles will require thrust vector control, thrust termination, thrust modulation

by **Norman L. Baker**

NEW YORK—The long-range second-generation solid propellant propulsion systems, in development or on the drawing boards, are beginning to complicate what until now has been the simplest rocket propulsion system. Until the advent of the large-grain ballistic missiles, *Polaris, Minuteman,* and *Pershing,* problems of thrust and directional control of rockets were essentially the headache of the liquid engine systems.

Tactical solid rockets, the limited range weapons, have used relatively simple control principles. Some of the solid rockets (*X-17, Honest John*) have their ballistic trajectory fixed at the time of launching, stabilized by roll about the longitudinal axis and fixed aerodynamic surfaces. Other solid systems (*Lacrosse, Hawk*) are capable of varying to a limited degree their direction of travel and distance traveled by command changes of aerodynamic control surfaces.

Most solid systems to date have operated within the atmosphere, where aerodynamic surfaces can hold the missile on a prescribed course once the longitudinal axis is positioned relative to the direction of travel. Current solid systems that have been used beyond the atmosphere (*Jupiter-C* final stages, *Vanguard* third stage) have been spin-stabilized before ignition to assure attitude control during powered flight with thrust cutoff velocity left to the pre-calculated performance of the solid grain.

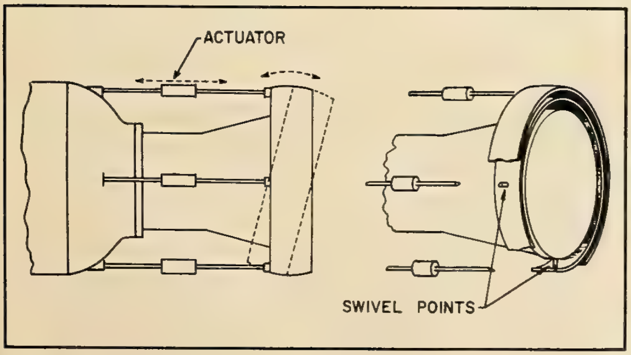
Changing the direction of travel of a solid propellant system has been limited to atmospheric missiles equipped with airfoil control surfaces which are effective during powered flight but diminish in value after burnout.

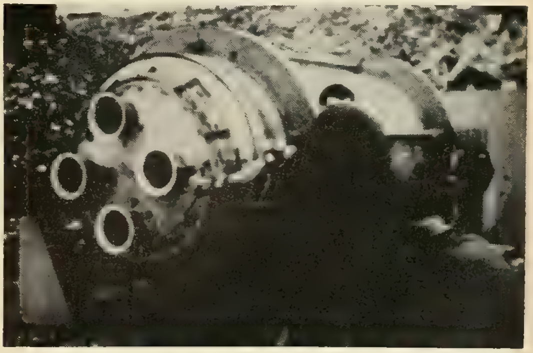
• **New controls needed**—The solid propellant control systems mentioned have been restricted to short-range missiles with a very small circular error probability. When the range is extended beyond 200 miles the precise attainment of roll control during powered flight, burnout velocity, and proper attitude (pitch and yaw) at burnout is of major importance if the payload is to impact or intercept a predetermined position. Except for a few rather short-range missiles (*Hawk, Falcon, Sidewinder,* etc.) most of the solid systems are simple free-flight vehicles that do not contain a guidance system and hence do not require a stabilized reference axis.

Now the precise control requirement, reaching a rewarding stage of development in liquid systems, is under investigation for the second-generation solids.

Dr. H. W. Ritchey, Vice President and Technical Director of Thiokol Chemical Corp., speaking at the 27th Annual Meeting of the Institute of Aeronautical Sciences here last week, discussed the control problems confronting solid propellant system designers. He listed three types of thrust control:

1). Thrust vector control. Control of the direction, which involves generating vectors along two axes perpendicular to the main line of thrust. Also, a torque can be generated around the main axis for roll control.





JETEVATORS ON EACH of the four nozzles in AX *Polaris* series are formed from two gimballed rings to deflect thrust.

2). Thrust termination.

3). Thrust modulation, involving adjustment of the amount of thrust at the command of some operational control.

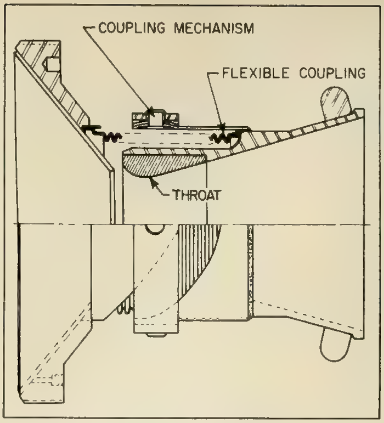
Thrust Vector Control

In addition to thrust vector control of the general direction and flight attitude of the principal vehicle, Ritchey said, moderate forces may be needed to correct for mechanical misalignment or gusts during periods of takeoff when external aerodynamic forces are not adequate to achieve control. Thrust vector control may also be needed at very high altitudes where atmospheric density is not sufficient to generate external aerodynamic forces.

A third need for such control may develop, the Thiokol official pointed out, in certain applications where the vehicle itself encounters flight regimes of aerodynamic instability. Some of these applications may require very high side vectors as well as very rapid speeds of actuation.

• **An old technique**—Thrust vector control was first obtained by use of vanes in the exhaust stream. Dr. Robert H. Goddard's rockets and the famed *V-2* used this method. Conventional application may require four jet vanes sometimes coupled with external control surfaces, if any.

Vanes in the exhaust stream have the advantage of providing roll control torques as well as side vectors when applied to a single nozzle. However, according to Ritchey, there are two principal disadvantages: (1) The attainment of large side vectors requires large vane surfaces and vane cross-sections, which introduce drag loss in the jet, and (2) Constant immersion of the jet vanes in the very high-velocity and high- temperature exhaust jet raises a difficult materials problem.



LATEST METHOD is gimballed nozzle attached to the combustion chamber by a flexible coupling.

• **The jetevator**—Very few materials are available that will permit long exposure to the hot gases of the rocket combustion; the desire for large side vectors has shifted thrust vector control investigations to applications of the jetevator. Ritchey says this device is a central zone of a sphere, usually mounted on gimbals, which dips into the exhaust jet in the direction desired to provide the necessary thrust vector.

In contrast to the jet vane, the jetevator is immersed in the exhaust jet only for the time the control forces are needed. However, it induces relatively high drag loss during the period it is used, and it cannot provide roll control unless the rocket engine is fitted with multiple nozzles.

The AX series of *Polaris* test vehicles, resembling closely the operational system, is reportedly using this method of control. Photos of static test firings reveal a form of gimballed jetevators on each of four nozzles.

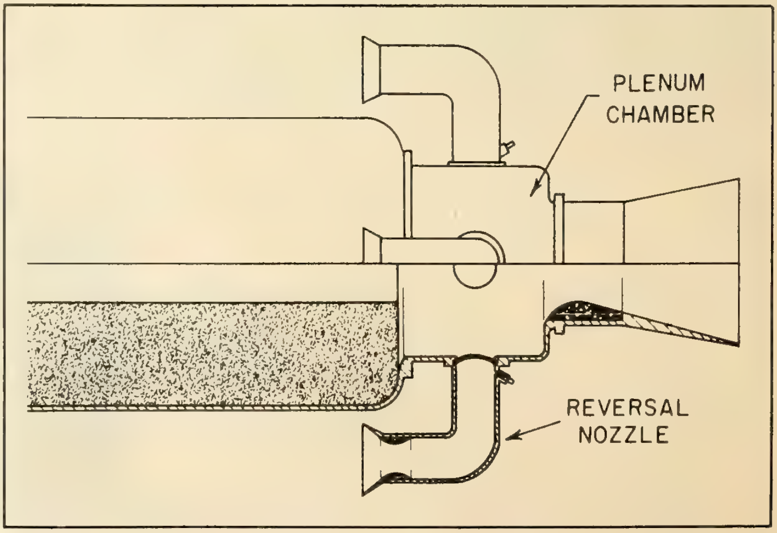
• **Nozzles favored**—The third device discussed by Ritchey is the flexible or gimballed nozzle, taking a page from liquid engine development. In the solid motor, the nozzle is connected by flexible coupling to the combustion chamber and is mounted on gimbals so that the exhaust jet can be diverted in any direction. Ritchey believes that from the standpoint of drag loss, this device should be the most efficient of the three. However, it brings in the mechanical problem of requiring seals against hot, high-pressure gas. And roll control can be obtained only from multiple nozzles.

Thrust Termination

Thrust termination of long-range ballistics requires command halting of thrust on attaining the proper velocity to provide the required range.

Thrust termination may be gained by generating an exhaust jet opposite the direction of the main propulsion stream. Ritchey said a reverse thrust equal to or slightly larger than the main forward thrust currently is being accomplished by generating a reverse jet through reversal ducts flowing into a plenum chamber at the aft end of the motor.

The first twenty-two *Polaris* test vehicles used this control system. The motor was a modified *Sergeant* with



FIRST 22 TEST vehicles in the *Polaris* series, using *Sergeant* motors, had four thrust reversal nozzles under lower skirt.

gases flowing into a plenum chamber and out through four nozzles aft, and four nozzles facing forward for reverse thrust. This system was affectionately tabbed "the octopus with the bends."

On the *Polaris* AX series, aft nozzles provide thrust, roll and vector control with forward end ducts (four equally spaced) supplying thrust termination and stage separation. On the staged *Polaris* the end ducts must be placed at an angle to the main axis so that the payload is not subjected to the head and shock of the reverse jet.

• **Some hazards**—Ritchey explained that both of these devices require some arrangement for rapid opening of the activation ports. He warned that the flight patterns of certain types of vehicles might be seriously disturbed unless all the ports are opened at exactly the same time and with exactly the same mass flow.

• **Dousing the fire**—Ritchey introduced another method of termination which involves quenching of propellant burning. He said this can be done by setting up a shock expansion wave inside the engine. A new nozzle throat area is opened which is larger than the initial throat area. This sets up a shock expansion wave inside the combustion chamber that extinguishes burning.

During transit of the expansion wave in the combustion chamber, this intermediate combustion zone expands and cools the surface of the propellant below combustion temperature, causing complete extinction of the flame. Under atmospheric conditions, the rocket can be expected to reignite after several seconds, but at high altitudes the intermediate combustion zone is so diffuse and the reaction so slow that combustion energy is not generated close enough to the surface to cause reignition.

Thrust Modulation

Dr. Ritchey explained that since thrust, as a first approximation, is proportional to the operating pressure of the engine, varying this pressure would seem to be the most direct approach to controlling the amount of thrust. He said it is necessary to open only very small ports of additional exhaust area to get a wide variation in pressure and thrust.

A scheme for modulating the thrust could use an externally-supported pintle arrangement, according to Ritchey, for varying the balanced auxiliary jets that are used for thrust modulation. Thus penalties for drag or other inefficiencies of expansion in the supplementary jet would have very small overall effect on the efficiency of the rocket.

R&D on Nuclear Missile Propulsion Decreases

WASHINGTON—The Atomic Energy Commission has released figures that show research and development on nuclear propulsion systems for missiles has dropped off in the past year. The $12.568 million spent for R&D in FY 1957 had dropped to $12.005 million in FY 1958.

Manned aircraft propulsion systems also experienced a reduction in R&D expenditures from $68.875 million to $62.222 million for the same period. Emphasis on the missile phase of nuclear propulsion experiments was placed on critical assembly measurements, propellant experiments, and studies of advanced missile concepts. General support work continued on advanced moderators, coolants, and structural materials.

Expenditures for satellite power sources, however, increased from $1.5 million in FY 1957 to $3.4 million in FY 1958, a 127% jump. The report, which specified the power sources were for use in "planetary satellites," did not give any further data on these units, but they are most likely of the type recently revealed at the White House.

The United States spent $107 million more for nuclear weapons research and fabrication in FY 1958 than in the preceding year. Weapons development and fabrication in FY 1957 amounted to $337.2 million, compared to an increase in FY 1958 to $443.9 million, a jump of 32%.

As of June 30, 1958, the AEC investment in plant and equipment for the production and storage of weapons showed a total of $781.8 million, and an additional $52.8 million in weapons test facilities.

Over the past eight years, the AEC's cost of operations in weapons development and fabrication rose from $163.6 million in FY 1951 to its present level of $443.9 million.

Capital Banquet Marks *Explorer I* Anniversary

WASHINGTON—*Explorer I* had its first birthday on January 31st and more than 700 people gathered at a banquet here to commemorate the event. The banquet was preceded by the presentation of a replica of the *Jupiter-C* launching vehicle for permanent display at the Smithsonian Institution.

Secretary of the Army Wilber M. Brucker, master of ceremonies at the banquet, introduced five speakers who each made a brief speech. They were Maj. Gen. J. B. Medaris of AOMC, Dr. Werhner von Braun of ABMA, Dr. William H. Pickering of JPL, Dr. James A. Van Allen of the State University of Iowa, and Dr. Maurice Dubin of the Cambridge Research Center.

Seventeen companies received awards from the Department of the Army and the George Washington Chapter of the Association of the United States Army for their participation in the *Explorer* program. They included Brown Engineering of Huntsville, Chrysler Corporation, Consultants and Designers of Arlington, Va., Cooper Development Corporation of Monrovia, Calif., Curtiss-Wright Corporation, Ford Instrument Company of Long Island City, General Electric Company, Globe Industries of Dayton, Ohio, Grand Central Rocket Company, Hallamore Electronics Company of Anaheim, Calif., Lodge and Shipley Corporation of Cincinnati, Rocketdyne division of North American Aviation, Osbrink Manufacturing Company of Los Angeles, Radiaphone Corporation of Monrovia, Calif., Reynolds Metals, Sprague Electric Company and the Waster King Corporation of Los Angeles.

Cosmic Rays Originate Outside Our Galaxy?

NEW YORK—Cosmic rays originate outside our galaxy, according to an M. I. T. physicist.

Dr. Bruno Rossi said recently he had drawn this conclusion from the fact that some primary cosmic ray particles have energies as high as 10 billion billion electron volts. This is about a billion times as great as the energy given to a particle in one of the largest man-made accelerators.

Speaking at the American Physical Society meeting, Rossi said a particle could not accelerate to this energy by traveling through all the magnetic fields of our galaxy. Furthermore, he said, particles of such tremendous energies come from all directions and not just from the plane of the galaxy.

Rossi said cosmic ray particles would create no hazard in space travel because there are so few of them.

In another paper at the meeting, Dr. S. Fred Singer of the University of Maryland said that some of the particles in the Van Allen doughnut-shaped radiation belts about the earth are from cosmic rays. The others, Singer said, are particles shot out from the sun.

Singer said the Van Allen particles are either protons or electrons trapped in the earth's magnetic field. Rossi said the cosmic ray particles are mostly protons.

Continued Growth in Military Electronics

Armed Services seeking those companies with electronics capabilities to serve as missile/astronautics prime contractors

by Raymond M. Nolan

WASHINGTON—A significant feature of the military electronics business today is that the armed services are awarding more and more prime contracts to companies with strong electronics capability. Latest indication of this is the award of the *Eagle* prime contract to Bendix Systems Division, Ann Arbor, Mich. Bendix thus joins a growing list of electronics companies charged with systems management of some of the biggest programs.

Among other such firms are Sperry with the *Sergeant*, Philco with the *Sidewinder*, Minneapolis-Honeywell with the *Wagtail*, and Sylvania with *Plato* (although the fate of *Plato* now seems to be somewhat unpromising).

The broad category of military electronics sales is estimated by Electronic Industries Association to represent 52% of total industry sales during calendar 1958. This was an increase of $200 million over calendar 1957 and adds up to a grand total of $4.1 billion (See EIA graph).

- **Sharp rise**—The missile electronics figures show an even more dramatic increase. During FY 1955, the total was $306 million. This climbed to $1.268 billion during FY 1958 and is expected to reach $1.5 and then $2 billion in 1959 and 1960.

This increase in spending results mainly from the shift in emphasis from earlier unguided or simply-guided missiles to more complex ones with more sophisticated guidance and control gear. In fact, more than 90% of the procurement dollars for missiles in 1959 are for weapons which were not produced in operational quantities during FY 1955. Long-range missiles will take more than half of the procurement funds during FY 1959.

In relation to the total defense budget, military electronics has risen steadily. Major procurement and production expenditures rose from 19% during FY 1955 to 29% in FY 1958. The percentage in relation to the total DOD budget including all categories has risen in the same period from 7% to 10%.

Air Force

In the split of missile electronics money, the USAF is far in front.

Two parallel programs are in existance for the *Atlas* and *Titan*. Originally, the *Atlas* was to use GE radio-inertial guidance and the *Titan* was to use Arma pure inertial guidance. However, it has been announced that *Titan* guidance will be used in the *Atlas* and that the first series of *Titans* will use a radio-inertial system developed by Bell Labs.

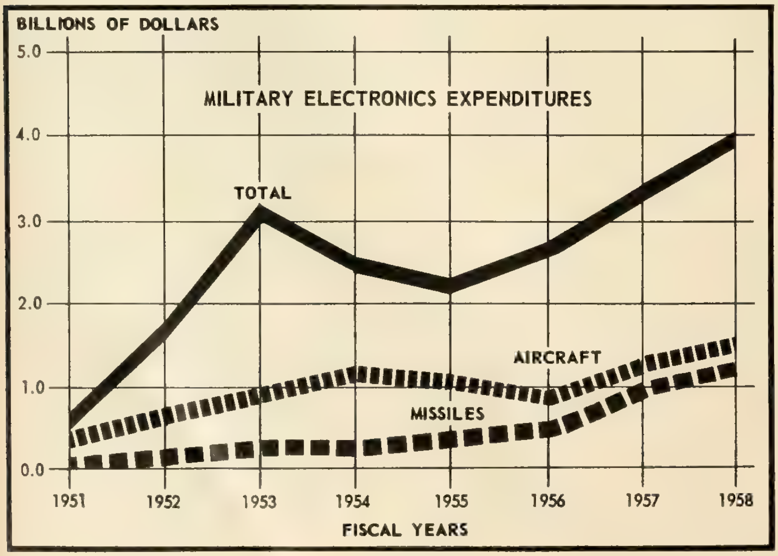
As for AF IRBM's, the *Thor* uses inertial guidance developed by AC Spark Plug and the Army-developed *Jupiter* has inertial guidance built by Ford Instrument Company. AC Spark Plug in another program makes the inertial guidance for the *Mace*. No word is out yet on who will build the guidance for the *Bold Orion*, the air-launched IRBM now under development by the Air Force.

The *Bomarc* program, which might easily become one of the largest in the budget, uses radar homing guidance manufactured by Westinghouse. Northrop manufactures the stellar-inertial guidance used on its *Snark*, but here the money figure is not too impressive because of the cloudy future of the *Snark* (although the Air Force awarded $50 million in contracts for *Snark* production last fall).

In the air-to-air category, the series of *Falcons* use either radar or IR, depending on their GAR number. Even-numbered GAR's use radar and odd-numbered GAR's use IR. The present *Genie* is unguided but there are reports that a guided version is under development. The *Sidewinders* that the USAF is buying also use IR. The old standby *Matador* uses radar guidance with a few modifications.

For its missiles of the future, the Air Force is staying with complex guidance systems. The *Minuteman* reportedly will use inertial guidance manufactured by Autonetics. The *Hound Dog*, with guidance also manufactured by Autonetics, is said to use a form of Doppler-corrected inertial system. No information has been released on the type of guidance used by the *Green Quail* and the *Wagtail* although the latter, since it is manufactured by Minneapolis-Honeywell, can be presumed to use some system incorporating gyros.

Sperry Gyro built the inertial sys-



INDUSTRY SALES BREAKDOWN

CATEGORY	1957	1958	PERCENT CHANGE	
Consumer Products	$1.7 billion	$1.6 billion	—	6%
Military Products	$3.9 "	$4.1 "	+	5%
Industrial Products	$1.3 "	$1.38 "	+	1%
Replacement Parts, Tubes, Semiconductors	$ .9 "	$ .86 "	—	4%
TOTAL INDUSTRY SALES	$7.8 "	$7.94 "	+	2%

GOVERNMENT SALES

BUDGET CATEGORY	FY 1951	FY 1952	FY 1953	FY 1954	FY 1955	FY 1956	FY 1957	FY 1958
Aircraft	$314	$ 632	$ 968	$1,085	$1,046	$ 999	$1,083	$1,446
Ships & Harbor Craft	34	56	106	97	90	79	81	99
Combat Vehicles	39	210	396	141	52	4	7	1.7
Support Vehicles	2	28	13	9	16	6	3	4.3
Missiles	11	91	159	159	306	628	1,108	1,268
Electronics & Comm.	193	597	1,001	827	636	771	880	875
Research & Development	136	209	253	248	244	267	303	3.8
Miscellaneous	18	106	146	100	64	48	41	38
TOTAL	$747	$1,929	$3,042	$2,666	$2,454	$2,802	$3,506	$4,050

em installed in the *X-15*. But no guid-nce manufacturer has been named or the *Dyna-Soar* because of the team ompetition now going on between oeing and Martin.

Army

The biggest money item in the rmy missile electronics budget could e the *Jupiter*—but it has long since assed to the Air Force for primary oney. This leaves the Army with the ld *Redstone* as its biggest missile.

The *Redstone* uses essentially the ame pure inertial system, manufac-ured by Ford Instrument, as does the upiter. But the *Jupiter* has an extra ccelerometer and a slightly different omputer arrangement because it has a wiveling engine instead of control fins ike those on the *Redstone*.

Bendix is just beginning to swing nto production on the inertial system or the *Pershing*. It will resemble that f the *Jupiter* but will be considerably maller. Another inertial system, manu-actured by Sperry and Minneapolis-oneywell,. is in use on the *Sergeant*.

The *Corporal*, because of its pro-uction status, represents a good share f Army electronics money. Its com-and guidance is built by the Gilfillan ompany. The surface-to-air *Hawk* ses radar homing developed and built y its prime contractor, Raytheon. The acrosse, an artillery missile, has ter-inal guidance manufactured by Fed-ral Telephone Labs.

In the *Nike* family, Western Elec-ric has a clear field, building command uidance for the *Ajax*, the *Hercules* nd the *Zeus*. Sylvania has the contract or *Plato*, the system which would use e *Nike-Zeus*, but there are reports at *Plato* may be on the way out.

Right now, the Army doesn't own n anti-tank missile. But three foreign irds are competing for the job—the erman *Kobra*, the Vickers *Vigilante* nd the French *SS-11*. All are wire guided with built-in electronics packages.

Navy

The biggest missile item that the Navy owns is, of course, the *Polaris* and it is on *Polaris* guidance that most Navy missiles electronics money is being spent. Because the *Polaris* will need some of its guidance system outside the missile, the money is split. GE makes the in-bird equipment and Sperry Gyro the SINS (Shipboard Inertial Navigation System) necessary for launching accuracy.

In the air-to-air category are the *Sidewinder*, with IR guidance; the *Sparrow III*, using the radar homing system built by Raytheon, and the *Bullpup*, with its Martin-manufactured radio command guidance. A group of air-to-air missiles are now on the way, but the only one whose guidance type has been revealed is the *Diamondback*, an IR type reported to be the successor to the *Sidewinder*.

The *Terrier* and *Tartar* as well as the *Talos* use beam-rider guidance manufactured by several different companies. All also use a type of homing direction, said to be passive for the *Talos* and active for the *Terrier* and the *Tartar*.

For the future, the Navy has several air-to-surface birds developing, such as the *Corvus*, *Crossbow*, *Eagle* (one of its uses), *Hopi* and *Raven*. No details of the guidance system of any of these have been released although it is rumored that Texas Instruments is building the system for the *Corvus* and it can be presumed that Bendix will provide guidance for the *Eagle*.

• **More to come**—This review did not even consider electronics fields which most certainly will take more and more of the missile dollar in years to come. One example is ground control and check-out. One knowledgeable missileman recently said that anyone who thinks of the missile as the bullet should consider the relative price of the gun to shoot it. This gives some idea of the role which ground support will assume in the future.

Turning back to research and development, it is almost impossible to conceive how much money has been and will be spent on electronic instrumentation necessary in design phases of missile programs.

Finally, there is the money which will be spent by the National Aeronautics and Space Administration. No figures are yet available but the R&D programs which must precede any of NASA's programs will take on added importance even though production money, because of the small number of units, will never be great.

Hercules Powder Says R&D Limiting Profits

NEW YORK—Hercules Powder Co., which established a chemical propulsion division in 1958, says the cost of research and development, and the uncertain duration of government contracts, will limit profits in this field.

Nevertheless, Hercules said in a recent report to stockholders, "in the national interest this work must be carried out, and with its long experience in the production of solid propellants, Hercules is a logical participant in the program."

Hercules, which has headquarters at Wilmington, Del., reported its 1958 net sales and operating revenue totaled $236,513,000, a decline of 4% from the 1957 all-time high. Earnings were $2.04 a share on common stock, 5% lower than in 1957.

Astronautics Tests

Jan. 30—The first in a series of *Nike-Hercules* cold weather tests was initiated. Successful kill was scored on a drone target dropped from an RCAF Lancaster bomber.

Jan. 30—*Thor* launched from Cape Canaveral in the 25th test of the IRBM and the 32nd flight of the *Thor* vehicle.

Feb. 3—*Titan* failed to leave its launching pad in the second unsuccessful flight test. Malfunction forced automatic shutoff of the engine.

Feb. 3—*Atlas*, last of B-series fired from Canaveral. Reported "successful," going about 4300 miles. Missile was 20th of test series.

Power . . . is not a complete answer . . .

. . . As long as we have people with ideas

. . . Very real competence in the services

This is not a new one . . .

Future of Electronics: Growth with Astronautics

EIA President David R. Hull gives a probing look at missile electronics today and predicts tomorrow's uses

Electronics Industries Association is the national trade association for the electronics industry. In this exclusive interview, m/r editors Raymond M. Nolan and Peer Fossen question David R. Hull, vice-president of Raytheon Manufacturing Company and president of EIA.

Q. What do you feel have been the significant developments in military electronics, as applied to the missile field particularly, during 1958?

A. It is always difficult to pin developments down to any specific given year, because normally the advance from conception of an idea to the practical product covers a span of years. However, I would say as far as 1958 is concerned, the two most significant developments may have been, first, advancements in materials and, second, improvement in power radiating in radio frequencies, particularly microwaves. In materials, we have seen much improvement in the semi-conductor areas leading to transistors, frequency and power-handling capabilities. Solar batteries can provide power for almost unlimited transmission time from satellite-telemetering radio transmitters, particularly when coupled with the semi-conductor devices just mentioned. Third, I would list the greatly improved materials for electronic parts such as resistors where we have tremendously increased temperature and humidity tolerances. On the power transmissions side, the backward wave-type device advancements certainly have given improved capabilities for interception of ICBM's.

Q. You mentioned advances in power transmission toward detection of ICBM's and yet there has been industry talk that our future in missile detection lies not in large power radiation, but rather in exploration of some magnetic phenomena or possibly infrared.

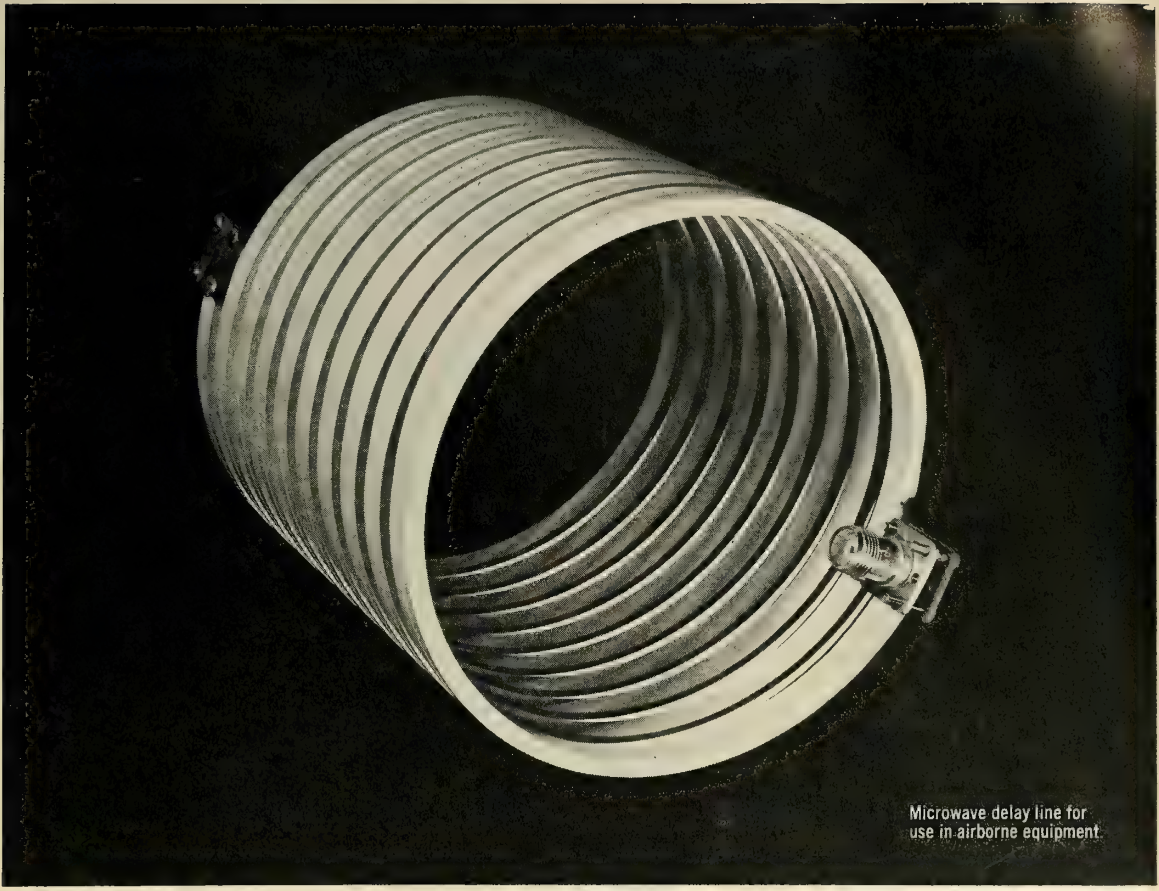
A. There are a variety of possibilities in this field. Power in itself is not a complete answer. In a complete radar system you have a combination of power and sensitivity. Again, getting back to basic materials, we certainly will improve the potential sensitivity receivers through our MASER developments. That is one combination which would be of tremendous help in a radar. On the other hand, we certainly have made terrific advancements in sensitivity in infrared devices. This gives us another avenue for long-range interception of missiles.

Q. Speaking of MASER, or if you like, molecular electronics, I wonder just what the future holds for the smaller manufacturer in that field? When you get in a cryogenic area, considerable capital is needed for research or development or for turning out products. Do you feel that, as we get more and more into solid state molecular electronics, smaller companies are going to have a place here or will it be the larger organizations?

A. I feel that smaller organizations have a very definite part in this picture. In fact, many now classified as small industry are active in development and have development contracts from the services or sub-contracts from larger organizations. These and all companies will play a very important part.

Q. Maybe we are speaking of different fields. I am thinking back to the classic success story in electronics: the fellow that could start in his garage and develop some product so that he could get his foot in the door as a subcontractor or possibly as a prime contractor for a military organization. It doesn't appear that someone on this scale is going to be able to get into this field where he has to have extremely low temperature capability and highly expensive components before he starts.

A. The capital problem is always hard on small industries but, on the other hand, there are tax concessions and other laws favoring small industry. I am convinced that as long as we have people with ideas we will have small



Microwave delay line for use in airborne equipment

MICROWAVE RESEARCH

The expanding role of electronic equipment in modern military operations has given high priority to microwave research. No field today offers greater challenge to the scientist and engineer.

In support of current electronic countermeasures programs and in anticipation of future systems requirements, Ramo-Wooldridge Division is engaged in microwave research to develop new techniques and to refine conventional components.

Research is under way at Ramo-Wooldridge for new methods and new designs to reduce substantially the over-all size, weight and complexity of electronic equipment for both airborne and ground-based uses.

For example, the low-loss delay line in the photograph above was designed, developed and manufactured by Ramo-Wooldridge for use in airborne equipment. Packaged for use in the system for which it was designed, this miniature ceramic unit weighs less than two pounds. It replaces a component which weighed more than twenty pounds and occupied more than five times as much volume.

Special opportunities exist for those with qualified experience in microwave research—in technique evaluation, component development, and design of such systems equipment—at Ramo-Wooldridge.

Engineers and scientists are invited to explore openings at Ramo-Wooldridge in:

Electronic Reconnaissance and
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Electronic Language Translation
Information Processing Systems
Advanced Radio and Wireline Communications
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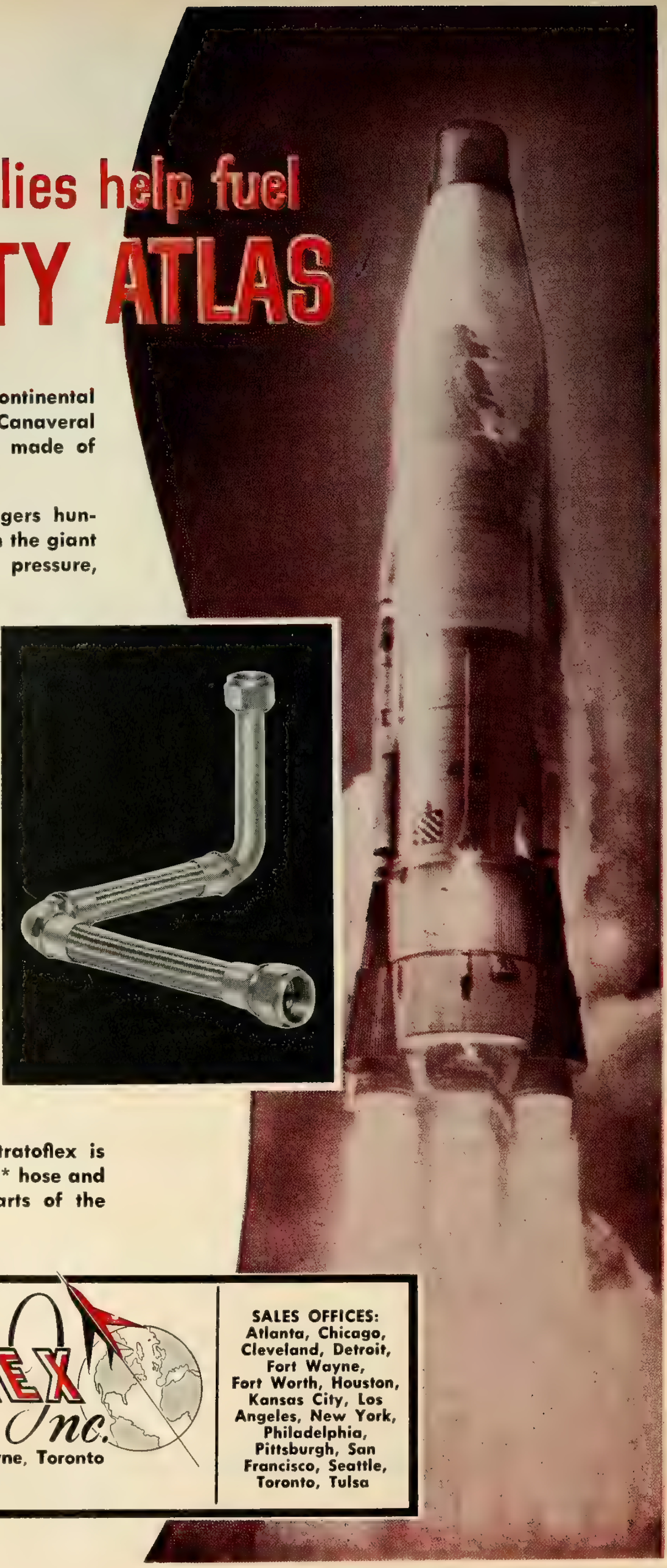
Stratoflex assemblies help fuel THE MIGHTY ATLAS



Every time a Convair Atlas intercontinental ballistic missile lifts from its Cape Canaveral launching pad, fantastic demands are made of the fueling system and powerplant.

A touch of the blast-off button triggers hundreds of simultaneous chain reactions in the giant ICBM's fuel system. Under tremendous pressure, liquid oxygen is delicately and precisely force-mixed with a kerosene-like fuel and flashes through the lines as vapor to feed the fires burning in the combustion chamber. This blend, mix, fire sequence must commence in a split second and continue at tremendous speed if the launch is to be successful. Fuel line plumbing on the Atlas must be absolutely leakproof, immune to strong vibrations, and able to withstand continuous temperature variations.

Despite the infinite possibilities for human mistake and material malfunction, the Air Force, aided by Convair technicians, has successfully launched the Atlas ICBM time after time at Cape Canaveral. (In the spectacular December 18, 1958 firing, the 85-foot Atlas was placed in orbit around the earth.) Stratoflex is proud that its specially-designed Teflon* hose and metal tubing assemblies are vital parts of the Atlas fuel line system.

* A DuPont trademark

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industries developing.

Q. Many people in the missile field feel that we have reached almost the ultimate in chemical propulsion. We can only advance from here by brute force, grouping rockets and so forth. Most people feel that the future is in several things such as plasma, ion and photon engines. Do you feel that these things could properly be termed electronic devices?

A. In a sense, you could term everything electronics if you reduce them to electronics. I have never considered propulsion as electronics. Electronics gets into propulsion through controls, telemetering and the like. You have a mix of arts, of course, when you get into the plasma approaches to propulsion, and in a sense the same thing in adapting nuclear power to propulsion. I would hesitate to give you a specific answer to this . . .

Q. I asked this question because an RCA scientist suggested in a recent paper that perhaps the real answer to controlled fusion is microwave ignition and containment, and that if this is the case, fusion becomes almost secondary to the way you contain and ignite.

A. This is in a sense what I meant by electronics having the control of any of these systems. It is hard to say at this state of the evolution just what will happen.

Q. A newspaper recently described an installation by Daystrom on a process control industry in Louisiana. Daystrom is guaranteeing with penalty clauses that their solid state process control unit computer will run at 99% efficiency for six months. Have you heard of this?

A. I have heard of it and I can believe it. As a matter of fact you can get really terrific reliability if you design to run components conservatively. The repeaters incorporating vacuum tubes in the transatlantic cables operate this way. They run very, very conservatively and I expect they will operate without any service for 20 years.

Q. Why don't we do this in military electronics?

A. Because military electronics is based on advancing the state of the art to a degree which doesn't permit conservative utilization of the pieces. You will find that practically every military specification requires something a little beyond what now exists. Therefore you are forcing pieces to do just a little more. You take what you have and hope you will have something better. In the meantime you bring the most out that you possibly can.

Q. Who expounds this philosophy? Are you in agreement with it?

A. Personally, no. This is one man's opinion. In too many instances we have advanced to a point of limited reliability and unfortunately beyond the average human operator.

Q. Who starts this? Who develops this philosophy?

A. It develops from the operational requirements. It is quite understandable. The buyers want something way beyond what they can see at hand. The technical people in the services in turn have to translate these requirements into specifications which really wring out the laboratory and the producer. I am not in any sense condemning anybody for this situation. I can well understand this desire for something advanced even at the expense of reliability.

Q. The problem today for almost anything in space flight and missiles seems to be power. We don't have it. We can't generate it efficiently. Where are we going to get the power? This is disregarding the solar devices we have now. Do you feel that someday within the realm of electronics we are going to be able to tap some of the energy available in space?

A. Yes, I do.

Q. Do you think this is the answer?

A. I think this might well be the answer. I think it is entirely possible that electronics as such can provide propulsion. I feel that before too long there will be a major breakthrough and that electronics in its pure sense will provide propulsion.

Q. Someone from General Electric said not too long ago he felt that one of our great assets was that within the commercial field we can develop products in pretty short order and compete with anyone in the world. His question was, why can't we do this with military products? You answered it somewhat, but I wonder if there is too much overengineering.

A. I think I will have to be critical of the military technical specification writers in this case. Too many times we have detailed specifications that go right down to the size of the nut and bolt. We should have the parameters specified—the input, the output and the performance—and give latitude to the individual engineer or engineering groups in the design. I am sure this would avoid a good 50% of the difficulty.

Q. Are the government people who write these technical specifications competent to do their job—more competent than the manufacturer they ask to produce the equipment?

A. There certainly is some very real competence in the services. There are some really dedicated people who work hard to insure that they are abreast of the art. They are faced with a very fundamental problem. They have to spell out the specifications in detail for honest competitive approaches. This is really the thing that binds them . . .

Q. In other words, as long as we have competitive bidding we will always be faced with this problem?

A. Yes, it will become more difficult as time goes on and systems become more complex. If advertised competitive bidding is continued, you will find the specifications becoming increasingly detailed rather than less so.

Q. What about weapons systems or the team approach? Isn't part of the philosophy in the weapons systems approach that the prime contractor or the team leader is given a little more leeway in specifying to his sub-contractors?

A. That is correct. The objective of the weapon system or team approach is very logical.

Q. I have heard some objection to it. That is, if two given services with vaguely similar objectives go out into weapons system development, the weapon system manager very likely could go to their next tier of sub-contractors for identical things and bring up the parallelism that the Department of Defense is trying to get away from.

A. This is a problem because you can take a device which will fit into two weapon systems and can find that manager A went to company X and manager B went to company Y. You could wind up with two totally different devices with the same end use and thereby complicate the service of supply.

Q. What do you do to prevent this?

A. I think a compromise is indicated. Where there are certain things common to various weapon systems, I believe that the services should maintain an element of control of what goes into a given weapon system to be sure there is no wastage of the type I just mentioned.

Q. We don't have anything like that now?

A. We had the other extreme, of course, before the weapon system was introduced. The end vehicle supplier complained because so many things were held closely by the military services and some didn't fit his particular vehicle. We have thrown the gauntlet to the weapons system approach with this weakness I mentioned. I think there should be compromise where the services have some control of what goes into weapon systems to avoid duplications.

Q. How would you mechanize such a compromise?

A. I think organizations within the services should have groups—project people if you like—to oversee each weapons system. All project groups should refer to a series of technical sections covering a variety of things, such as engines and navigation equipment, to find which is the best development in a given technical speciality for use in each weapon system.

Q. Since they would be joint groups, who would administer these project and technical people? Would this come under ARPA, maybe, or directly under DOD? I ask this because it seems unlikely that they are going to any new committees in DOD.

A. Well, as much as I hate to see the services seemingly submerged, I do think that in this space era we need the consolidation indicated by the formation of NASA for the non-military and the ARPA group for the military applications. I further feel that to solidify space weapons it is essential that this authority be lifted above any given military service and given technically to a single group in order to eliminate inter-service rivalries.

Q. I'd like to ask you a question about a point—I've heard some criticism lately about military philosophy being dictated by educators.

A. This is not a new one.

Q. I realize it is not a new one, but I sometimes wonder if perhaps the pedantic nature of educational minds doesn't in some ways impede our progress?

A. The biggest problem comes from military operating people coming in contact with scientific "long hairs" who are enthusiastic about their fundamental ideas and who also have no idea of problems involved in trying to squeeze out an operational device from a thought in about two months.

Q. Would you say this was insecurity on the part of the military?

A. No, not really insecurity. But obviously they are grasping for advanced ideas, which gets back to some of my earlier comments on the problems of translating an operating requirement to a practical device and the bugs that are inevitable when you try to rush it.

Q. My next question concerns how to improve R&D and speed it up. I think you have pretty well answered this, but I would like to extend it a little bit and ask you what EIA is doing?

A. EIA has a very strong engineering department with headquarters in New York. It has many committees covering a wide variety of products. This is a group means of injecting information into both engineering and manufacturing in order to bring out the best and most practical ideas as to what will go together . . . This is not a static group; it's a forward-looking group. It is not confined to EIA membership. As a matter of fact, as many non-members companies participate in our engineering committees' activities as member companies; so we have a very good sounding board. This part of our organization works very closely with the electrical standards group located in Red Bank toward setting the parts specification used by the military. We are doing our utmost at EIA to insure the best possible equipment consistent with the state of the art and at the same time are looking forward to the future.

Q. What sort of reception do you get from DOD?

A. As a matter of fact, we have had a greatly improved reception in DOD. We give the services what is now available and at the same time generate some specifications which we can foresee as attainable at certain stages in the future. You'd stagnate advances if you did not do so.

Q. I certainly agree, I was just curious—you say the reception has been greatly improved and I take it that it wasn't too good in the past?

A. That is correct, but on the other hand we now have created such relations with DOD that we are having EIA specifications which are realistic accepted and translated into military specifications.

Q. Speaking of the industry in general, do you expect that the dollar volume of electronics will remain constant—I'm thinking about a constant growth rate—or will there be large jogs upward even without significant breakthroughs?

A. There will certainly be an increase in the slope simply because the electronic content of so many things is increasing. By just normal growth plus this increase you can expect a steeper slope and therefore a greater increase in the rate of electronic growth than that of other industries. The breakthroughs may come to cause these jogs you mentioned, but obviously you can't forecast them. There may be some, such as the power which I hinted at a while back . . . We look back only a quarter of a century and see airplanes with a tachometer, roll and bank indicator and airspeed indicator. This was the total instrument content without any electronics. Now we see aircraft with a whole variety of radar devices for bombing and interception. We see navigation equipment, communication equipment, missile guidance devices, electronic counter-measures. You run a whole gamut of things in many cases covering over 50% of the cost of the aircraft or missile or vehicle or whatever it may be . . .

Q. Well, someone said recently that there was quite a future for electronics in electronic counter-measures, missile detection and what-have-you in the Antarctic. Have you thought about that?

A. Yes, I've certainly thought about it. We can't restrict our thinking to any point of this globe anymore. If you look at the defense installations, we have been considering the shortest possible paths. But why limit ourselves to that? We put our weakest defenses in the other areas, so why shouldn't a potential enemy seek out those areas for his approach? The Antarctic cannot be disregarded.

Q. Within the aircraft industry over the past 15 years we have been looking at what you might term a shake-down. Many small or weak companies fell by the side and there was a gradual pattern of growth until you have the member companies of Aircraft Industries Association today—big, strong companies that control the aircraft industry pretty tightly. I wonder if this isn't going to be the pattern with electronics. You quoted the analogy a while back of airplanes a quarter of a century ago—I wonder if electronics won't experience the same thing that the aircraft industry is.

A. Well, frankly I don't foresee it at this point. Certainly there are some advantages in large companies with plenty of capital having the ability to set up basic research groups which would contribute to their growth. But we certainly have found many break-offs from these large companies where individuals or small groups have been able to make a go of whatever product resulted from their particular pet ideas and grow from that. As a matter of fact, if you take any existing large company and look back to its inception you will find there was an individual who had an idea and started an organization.

Q. That is true, but that isn't really what I meant. For every one of those companies that breaks through this way and becomes large because of a good product, luck, or what-have-you, many other companies who would normally still be in business with a small product and not too great a demand aren't in business anymore because a larger company has assimilated their function—you can certainly appreciate this in the electronics business, I imagine . . .

A. Yes, there is a tremendous amount of assimilation, so the companies that have been actually going out of business through failure or bankruptcy are very few. We won't get into statistics along these lines—but there has been a lot of amalgamation. However, you will note in these absorptions that usually the small becomes a significant part of the large.

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Specifications

Actuator load (range)	*90 to 150 in. lbs.*
Electrical input (nominal)	*28 volts DC—10 Milliamperes*
Pressure range	*500 to 3000 psi*
Rated flow	*½ to 2 gpm*
Mounting	*Manifold*
External leakage	*None*
Proof Pressure	*4500 psi*
Burst Pressure	*7500 psi*
Temperature operating range	
Fluid	*-65°F to 450°F*
Ambient	*-65°F to 750°F*
System filtration	*10 microns*

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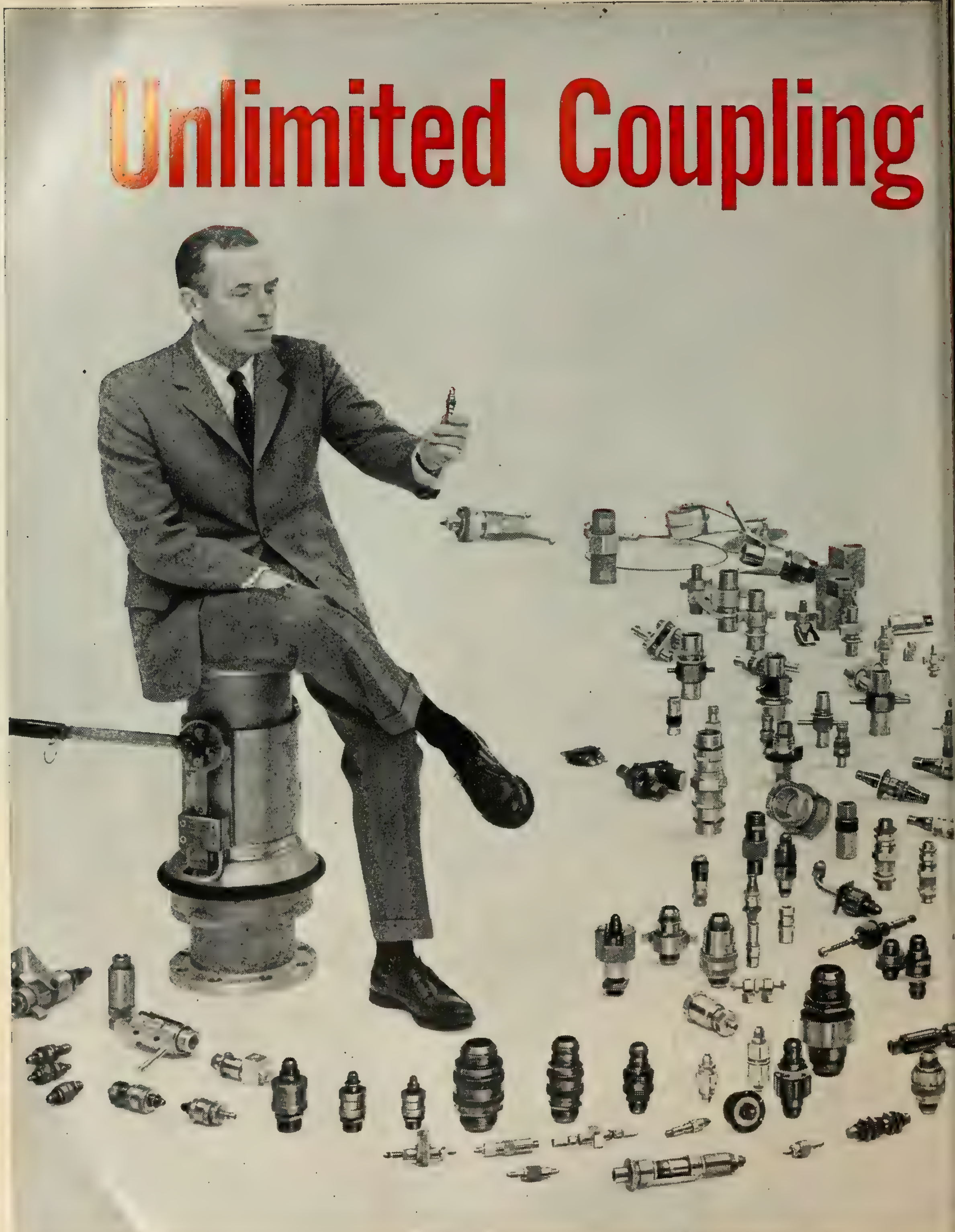

Tremendous range of Aeroquip Coupling designs is demonstrated by B. A. Main, Jr., Vice President of Engineering, seated on a 10-inch coupling while holding a miniaturized coupling in his hand. The couplings shown here are only a few of the infinite variety developed by Aeroquip for use with hydraulic fluids, ordinary and exotic fuels, gases, oils, air, liquefied gases, ammonia, nitric acid, ethylene oxide and many other fluids.

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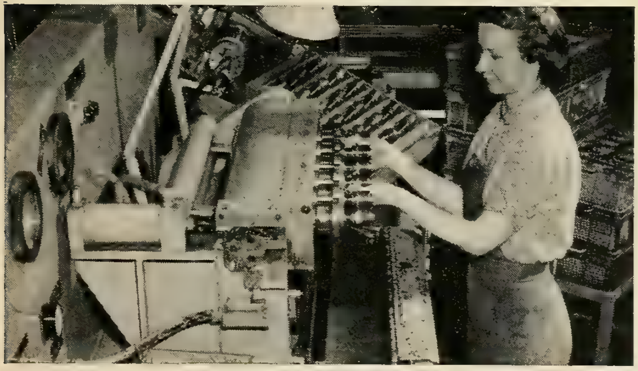
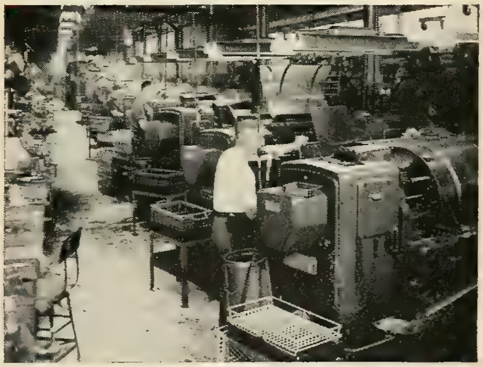


Aeroquip's high standard of reliability is assured by final proof testing of all couplings. The proof test machine pictured above was specially designed by Aeroquip for maximum dependability and speed. Final testing follows numerous quality control checks during production.

Birthplace of many new coupling designs is this modern design section in Aeroquip's development-engineering center at Jackson, Mich. Another engineering staff is maintained at the Western Division in Burbank, Calif., which also produces couplings.

Testing equipment that duplicates conditions ranging from arctic cold to the searing heat generated by jet or rocket engines in flight is included in the development-engineering section, at Jackson, which occupies over 15,000 sq. ft. of floor space.



Production facilities in the Jackson plant include this battery of automatic screw machines. Complete manufacturing operations are duplicated in Aeroquip's Western Division plant.

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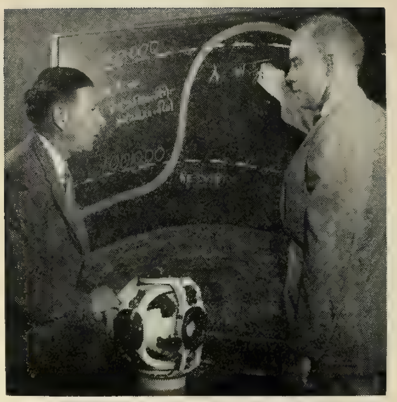
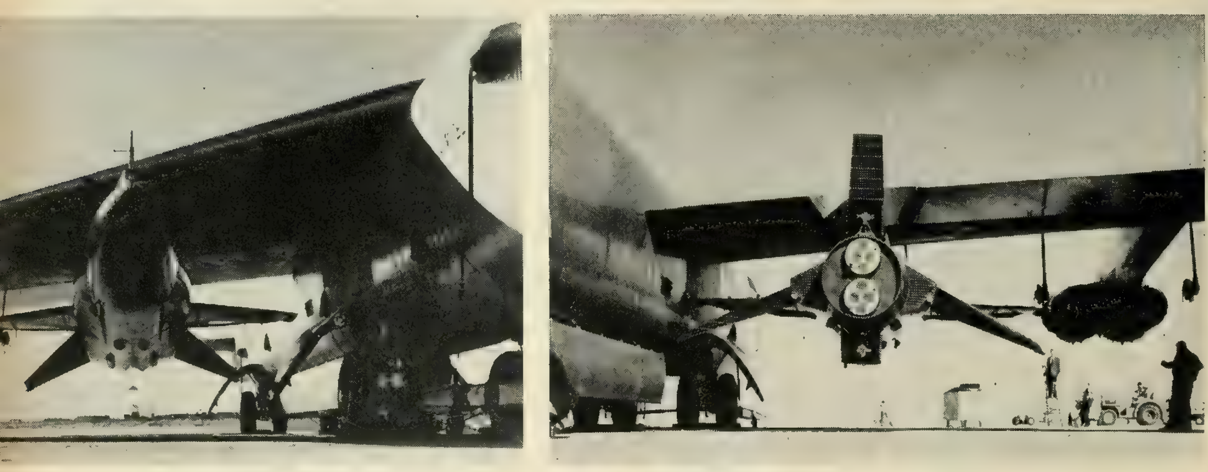
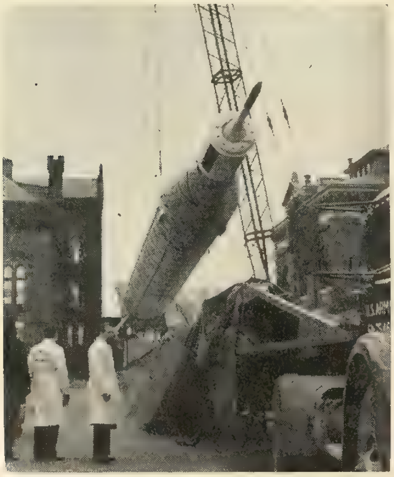
astronautics in the news . . .



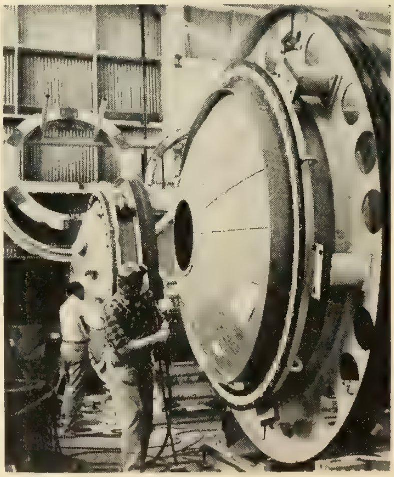
HEART OF THE ***X-15*** **inertial guidance system developed by Sperry Gyroscope Co. First of six systems was recently delivered to Edwards AF. Dr. Carl Frische 'left' president and Nathan P. White, discuss system.**



X-15 **ROCKET-POWERED high-altitude research craft attached to its pylon under the wing of the B-52 mother ship. Three main fittings secure the** ***X-15*** **and additional quick disconnect lines allow a launch panel operator in the B-52 to feed nitrogen and LOX to the rocket ship.**



REPLICA of the ***Jupiter-C*** **rocket and the** ***Explorer 1*** **satellite was presented to the Smithsonian Institution last week.**



TANK BULKHEAD section of ***Thor*** **is attached in large rotating fixture at Douglas plant.**

Space Navigation Poses New Requirements

Automatic, self-contained inertial systems will be required to provide precise velocity vector control

by Frederick Stevens

Manager, Electronic Systems & Equipment, NORTRONICS Division, Northrop Corporation

HAWTHORNE, CALIF.—Present navigational art, which man has developed so painfully over the centuries, will be of little use to him in the age of space exploration, now irrevocably upon us.

Traversing the enormous distances of this and other solar systems will require a great revolution in the science of automatic navigation.

The rudimentary navigational techniques now being used in early efforts to probe space will soon become inadequate. In a very short time we will be in a sort of "mid-period" of space exploration when vehicle control by radar tracking and radio command will lose its effectiveness because of the square-law degradation of radio signal strength with distance.

As we move into this mid-period of high-orbiting earth satellites and systematic space probing, it is clear that we must utilize to an increasing extent automatic, self-contained guidance systems, carried on board the space craft, which can provide very precise control of the velocity vector.

• **Technique is there**—Luckily, a technique for automatic navigation of space vehicles during the mid-period is in existence, requiring only refinement and adaptation for space travel. This technique is the outgrowth of intensive research and development for intercontinental guided missiles, and the result of a technological revolution in automatic terrestrial navigation which began during and shortly after World War II.

The technique, of course, is inertial guidance, which involves the sensing and suitable interpretation of accelerations acting on a vehicle traveling through inertial space. A gyro-stabilized platform provides an inertial reference, and accelerations are sensed by accelerometers. Acceleration signals are integrated to obtain a measure of a present velocity vector. A second integration yields "space position." Computers are employed to maintain a "track" and to predict the ensuing trajectory of the vehicle.

• **How it began**—In this country, inertial guidance had its origin in the laboratories of intercontinental guided missile contractors shortly after World War II, when military requirements as well as certain technological advances in the gyro and electronics fields made it possible to construct satisfactory systems.

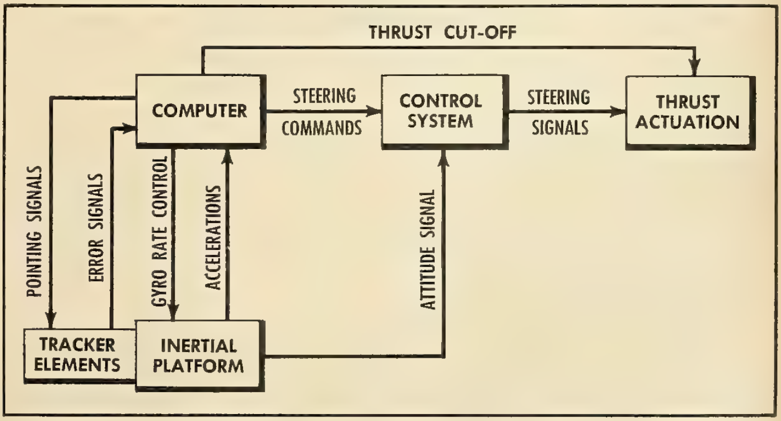
Systems development has proceeded along two lines. Inertial systems of the "pure" variety have been developed and used where relatively short periods of operation are involved and where the inherent tendency of gyroscopic mechanisms to drift will not seriously disturb system accuracy. Hybrid or "aided" inertial systems have been developed for application to intercontinental "cruise" type missiles where relatively long periods of system operation are encountered.

Hybrid systems employ additional and sometimes redundant monitoring subsystems to correct for gyro drift and other errors. Chief among these monitoring subsystems are automatic star trackers, capable of tracking a wide variety of navigational stars during broad daylight as well as during the hours of darkness. Stellar data is used to periodically reorient the inertial platform. Radio "aids" are also utilized for monitoring purposes, transmitting position and velocity information to the system.

The success of these systems in providing very accurate guidance for intercontinental guided missiles is well known. Most of the important ballistic missiles have "pure" and radio-inertial systems which provide accurate velocity control in the boost phases of flight.

• **Research continues**—With inertial systems of various types in quantity production for most of the operational and near-operational intercontinental missiles in our inventory, considerable research and development for more advanced applications of inertial guidance principles is in progress, including techniques for enhancement of system reliability.

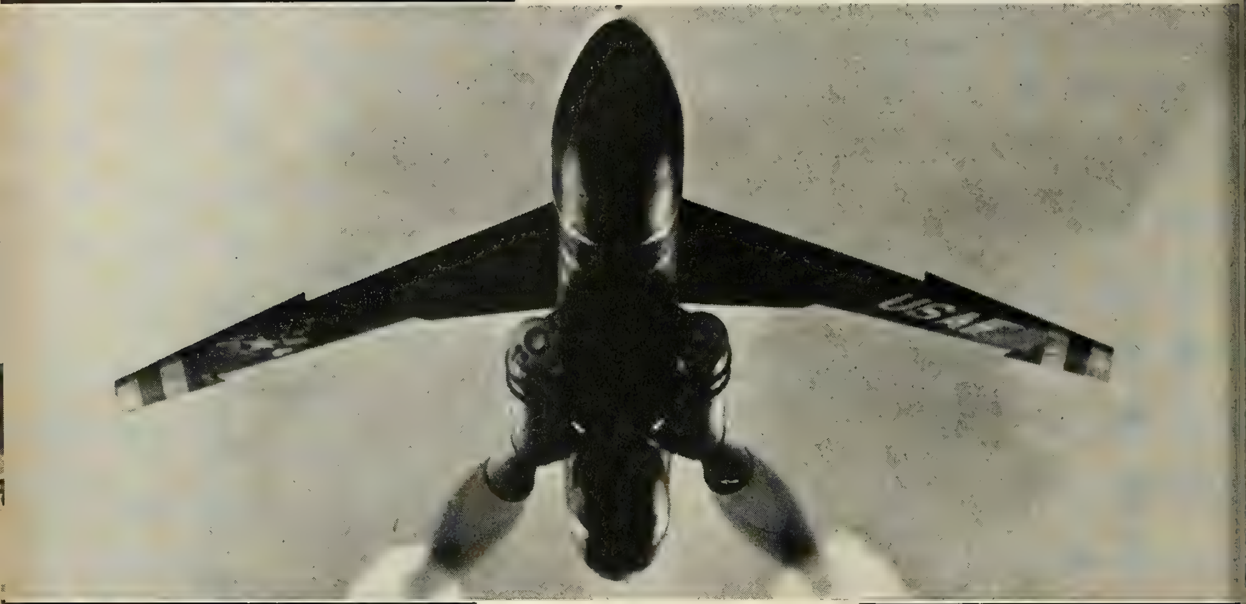
The current trend is towards system miniaturization, and inertial systems of the "pure" and "aided" variety with a total system weight equivalent to the weight of a human navigator will soon be available. Miniaturization has been made possible by advances in the solid state electronics field, by more sophisticated system design, and by refinement of platform stabilization and acceleration sensing techniques. There is also a trend towards digitalization of inertial sensing elements, undoubtedly permitting great size and weight reduc-

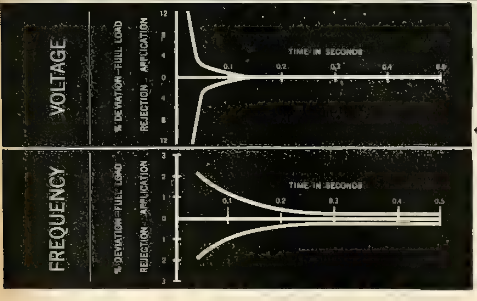


RELATION OF guidance system elements to velocity control and cut-off.

engine power BY CATERPILLAR

CATERPILLAR POWER FIRES SNARK...FIRST U. S. INTERCONTINENTAL MISSILE





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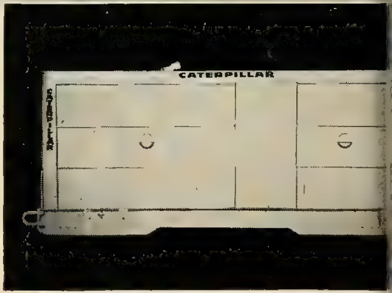

The U. S. Air Force SNARK SM-62, the first U. S. intercontinental guided missile, is fired with power from an electric set, developed by Caterpillar and now being supplied to the military.

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Creative engineering and quality of manufacture make Caterpillar the diesel leader. For detailed information on the Cat 60 KW 400-cycle portable power unit or other Caterpillar Engines, write to Engine Division, Caterpillar Tractor Co.

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tions and increased accuracy.

The advanced state of the inertial guidance art will soon permit systems capable of providing very accurate space navigation. Current technology can solve navigation problems during the coming mid-period.

• **Likely types**—The inertial system in space will resemble inertial systems for terrestrial navigation. There will be the usual gyro-stabilized platform, somewhat more sophisticated in design than the terrestrial platform. Because of the problem of gyro drift, which may never be completely solved, there will be a gyro-monitoring subsystem—undoubtedly a tracking device. For earth orbits, it will track the horizon of the moon or other planets, or perhaps the sun. For lunar orbits or for exceptionally high earth orbits, it will track fixed stars.

The tracking subsystem will perform essentially the same function that it has in the "aided inertial" terrestrial system described previously. There will be acceleration sensing devices mounted on the inertial platform, and there will be an airborne computer.

For the navigation of near-earth satellites and early lunar and space probes, a "pure" inertial system would perhaps be adequate, without tracker elements. In this case, there would be a "pure" inertial platform, with three gyros, three accelerometers, and four gimbals for all-attitude reference. This would not, however, provide the accuracy needed for precision interplanetary navigation.

In precision navigation of earth satellites and lunar and space probes, tracker elements would be required. In addition to the three-gyro, three-accelerometer, and four-gimbal platform, there would be three or less automatic telescopes for maintaining platform orientation in inertial space. Such a system would be entirely adequate for all but the most extended of interplanetary missions. If manned interplanetary missions are to be considered, planet trackers may be added to the system in order to improve the accuracy of intermittent position fixes.

• **Reliability stressed**—One of the chief problems in the development of inertial systems for space navigation is that of reliability and the attendant implications of component reliability. Fortunately, existing inertial guidance technology provides solutions to this problem. Component reliability techniques have been developed to provide unusually high reliability for terrestrial systems.

The inertial system in space will perform two basic functions, though there are necessarily many collateral functions. It will provide very accurate velocity control, and a constant indication of position in space.

• **Velocity control**—Velocity control will be achieved through instantaneous sensing of changes in the speed and direction components of vehicle velocity. While a vehicle is in a "parking" orbit, accelerometer signals are, of course, null. While the vehicle is moving towards the point of entry into orbit, however, craft accelerations, when singly integrated and compared with predicted velocity, will serve as control signals for placing the craft in orbit. Precision onboard velocity control will be particularly useful for positioning space vehicles in orbits, especially in the more exotic orbits where very high accuracy will be required.

One of the most interesting exotic orbits is the so-called 24-hour orbit permitting a vehicle in effect to hover over a given point on the earth's equator. To achieve such a useful orbit, it will be necessary to place a vehicle into orbit altitude with great precision. This will not be conveniently done solely through radio transmission of velocity data acquired through radar tracking. The altitude of the 24-hour orbit will be slightly above 23,000 miles, where signal degradation and time delay will be excessive. But an inertial system, being entirely self-contained, will provide instantaneous and continuous velocity data, with no time delay and no signal degradation. A suitably accurate trajectory to the point of orbit can thus be maintained.

• **Position data**—The inertial system will provide positional information in two ways. During periods of thrust, the system will operate much as it does in terrestrial missiles. The inertial platform will remain stable through the operation of platform gyros, and periodic platform stabilization will compensate for gyro drift by means of earth, sun, or star tracking. Accelerations will be sensed by platform-mounted accelerometers, and double integration of acceleration will obtain positional data.

Once a vehicle enters an orbit, however, there will be no accelerometer output because of the zero-g environment. Nonetheless, the system will have observed precisely the velocity of the vehicle at the moment of entry into orbit. If a computationally-derived measure of mass attraction forces is available, that observed velocity may be used by the inertial system computer to give a constant indication of position in orbit.

Positional data will be used in directing the vehicle from one orbit into another. The inertial system computer will initiate thrust at the exact point of escape. Thereafter, during cruise to the new orbit, the inertial system will provide position information which may be compared with data for a standard trajectory. Periodic corrections may be made to guarantee arrival at destination.

In a like manner, positional data will also be used in providing for escape from orbit to return to the earth or to land on other planets.

• **Side jobs**—In addition to velocity control and positional indication, there are collateral functions which may also be performed by the system. One difficult problem encountered in orbiting vehicles to date is tumbling, which disturbs the radio transmission of observed data and destroys the zero-g environment which may be desired for certain observations. The inertial system will sense this tumbling, thus permitting a corrective thrust application. Conceivably, by utilizing the principle of conservation of angular momentum a gyro-controlled platform could eliminate tumbling by selective programing into the platform gyro wheels of changes in angular momentum.

It is also conceivable that power could be taken from the stored energy in gyro wheels by running spin motors as generators during periods when power generation through solar energy is not possible.

One interesting possibility is the use of paired inertial systems for measuring gravitational gradients. Relative position in space could be thus determined by reading gravitational differences. Accelerometers sufficiently sensitive to perform the sensing function are not yet available, but they may be on hand in the near future.

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Midcourse Guidance Is Necessity for Interplanetary Travel

Venus flight would require orbit about the sun and eventual capture by planet

by L. T. Seaman

Manager, Navigation and Control System Design, Missile and Space Vehicle Department, General Electric Company

PHILADELPHIA—Space navigation may be defined as the means to measure the present position and motion of a space vehicle, to predict its future position and motion, and to apply orbit trajectory corrections so that the vehicle will reach a point in space at the same time the destination planet or moon is there.

The three functions—measurement, prediction and trajectory correction—are interdependent. This article illustrates the basic relationship between the accuracy of position measurement and the propulsion power required for trajectory corrections.

The general field of navigation of space vehicles includes launch guidance, midcourse guidance, and terminal—or landing—guidance. We are chiefly concerned here with midcourse guidance, which extends from cessation of launch guidance at booster burnout until the vehicle lands on the destination body or goes into orbit around it.

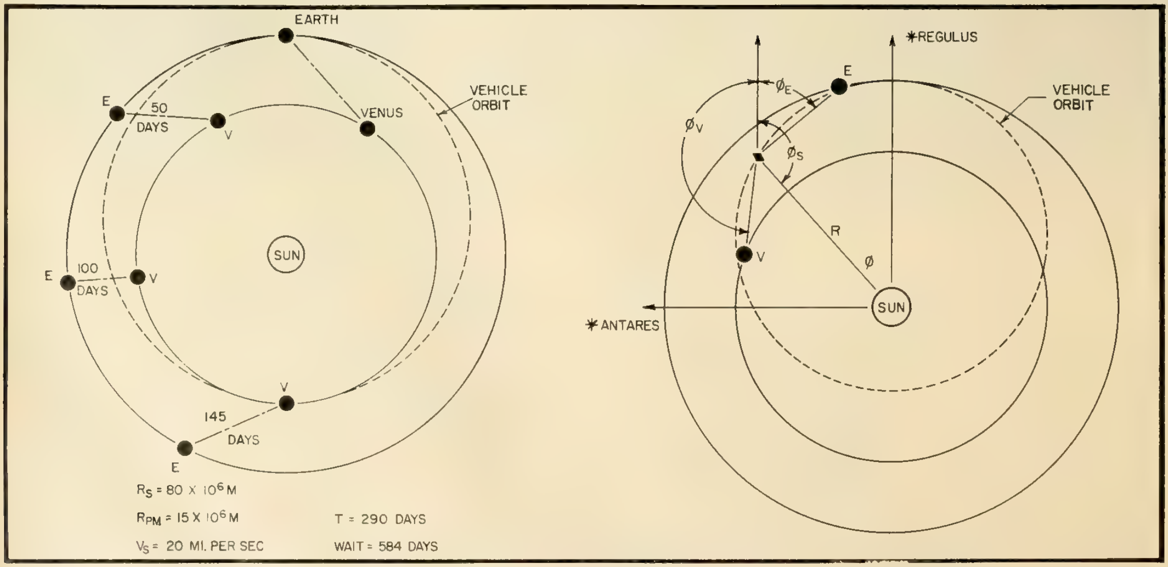
- **Present limitations**—Systems already are being developed for applications ranging from earth satellites and lunar probes to interplanetary vehicles. But the present limitations of launch guidance are demonstrated by the recent moon probes.

These lunar probes show that man is now or will be in the very near future, able to place a space vehicle at a range of the moon's orbit radius to an accuracy of one lunar diameter. However, applying this launch guidance ability to the more demanding field of interplanetary travel would result in intolerable misses for even the nearest planets. Midcourse guidance will be a necessity.

- **A Venus flight**—To illustrate the problems of space navigation, let's consider a trip to the planet Venus. It would be done in three phases:

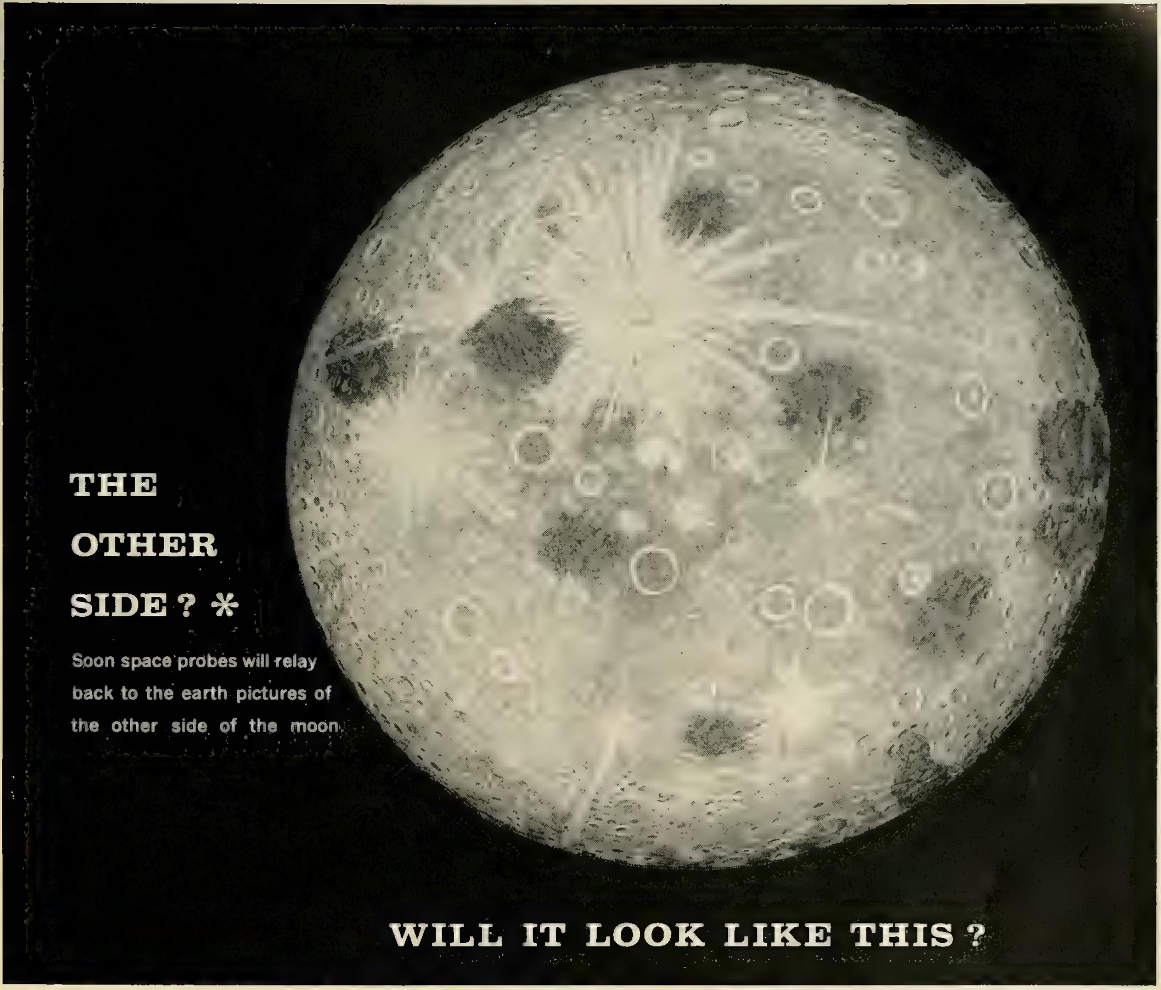
1. Escape from earth's gravitational field. This may include an intermediate earth orbiting phase for refueling or improving launch guidance accuracy.
2. Orbit about the sun. The orbit must intersect Venus' orbit at a time when Venus is at or near the point of intersection.
3. Capture by the planet. This includes cutting or modifying the vehicle velocity so that an orbit about Venus or a landing is attained.

- **Midcourse**—Phase 2 involves the longest time and distance. The space vehicle will be so remote from the planets that active means of navigation such as radar will be difficult to use. The sun's gravitational field is predomi-



MINIMUM ENERGY orbit transfer shows it would require 145 days to traverse 250 million miles (Figures 1 and 2).

* *This scientific representation based on current knowledge was prepared under the supervision of Dr. I. M. Levitt, Director of the Franklin Institute Planetarium.*



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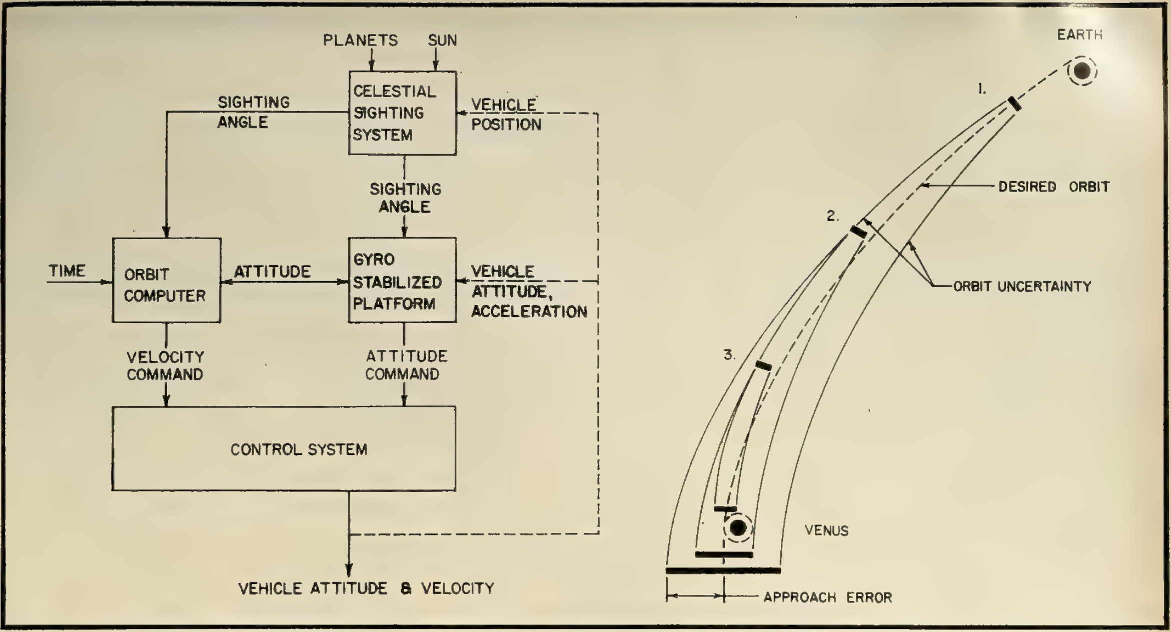

BLOCK DIAGRAM of a space navigation system including reaction thrust for stabilization. (Figures 3 and 4)

nant from at least 150,000 miles above the surface of Earth to roughly the same distance above Venus, or a third of that distance above Mars. At these altitudes, the force of the sun's gravity equals that of the planet for an object located on the line between them.

A minimum energy orbit transfer between Earth and Venus is shown in Fig. 1. It illustrates the immense distances, high velocities, and long periods of time that are characteristic of space travel. The space vehicle is roughly 80 million miles from the sun and 15 million miles from the two planets at the midpoint of its flight. It is moving at an orbital velocity of roughly 20 miles/sec. (its velocity relative to the planets is, of course, less than this). The journey to Venus requires 145 days to traverse a total distance of 250 million miles.

Although the minimum energy orbit requires the least propulsion power for a trip to a planet, it has the major disadvantages of long flight time and restrictions of launch time. The vehicle must be launched when the two planets have the relative positions shown in Fig. 1. If the launch is delayed due to mechanical or other difficulties, it must be delayed 584 days until the planets assume the same relationship again. For this reason alone, non-minimum energy orbits are highly desirable.

- **Basic measurements**—An example of the general measurement problem in space travel is shown in Fig. 2, which depicts a non-minimum energy flight from Earth to Venus. The space vehicle is shown at an intermediate position that is defined in polar coordinates. Rectangular coordinates may as easily be used and the selection of either will depend on any computer simplification possible.

The ecliptic planes of Earth and Venus differ by 3° 24′ so that the navigation problem is not coplanar as indicated.

The reference coordinate system can be accurately set up by star sights. A trajectory plane parallel to Earth's or Venus' ecliptic plane may be chosen. As shown in Fig. 2, the first magnitude stars, Regulus and Antares, since they are approximately 90° apart and near to the ecliptic plane, may be sighted to establish the trajectory plane. The star Polaris may be used to determine the normal to this plane, if compensation is made for its declination from the Earth's ecliptic pole of 23.5°.

If the accuracy of instrumentation warrants, compensation for the stars' heliocentric parallax may be made. However, this effect is small—the nearest star, Alpha Centauri, is 4.3 light years away and has 0.76 seconds parallax.

To determine the vehicle's orbit, and to predict its position error on arrival at Venus, we must measure position, velocity, acceleration, attitude, and time.

- **Position**—The location of the space vehicle may be determined by sighting three celestial bodies such as Earth, Venus, and the Sun.

Alternate means of position measurement include radar or the inertial guidance method of double integration of acceleration.

- **Velocity**—Velocity is a derived quantity based on either the integration of acceleration or the differentiation of position. The former is suitable for short time periods and for powered flight conditions, and therefore, is useful for trajectory corrections made during orbital flight.

The method of position derivative is the best means of determining velocity during orbital flight. It may be expressed as

$$V = \frac{d}{dt}(s) = \frac{S_1 - S_2}{t_1 - t_2}$$

Its accuracy increases as the time interval between position readings increases. For this reason, and because the trip to Venus may take over 100 days, velocity calculations probably will be made with an "averaging" period of over one day.

The doppler principle of measuring range rate may, in theory, be used to measure velocity. However, present radars are not equal to the range requirements. The doppler effect in the visual light spectrum has been used to determine the speed of distant stars. However, its accuracy is in the order of miles/sec. and, therefore, inadequate for space navigation.

- **Acceleration**—The measurement of acceleration during trajectory corrections may be made with today's precise accelerometers. An accuracy equal to that of ballistic missile guidance sys-

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tems is adequate.

• **Attitude**—The attitude of the space vehicle must be known accurately during trajectory corrections to align the control rockets to the desired orientation. Attitude may be determined by celestial tracking and by a gyro-stabilized platform. Long-term corrections for gyro drift will be made from the information obtained by celestial tracking.

• **Time**—The measurement of time is all-important to space navigation. Accuracy may require relativistic corrections to the apparent time.

Once the orbit of the space vehicle is known and its approach position error at Venus predicted, the orbit may be modified to reduce this error. Trajectory corrections may be made by a short-duration reaction impulse that generates a pre-computed vector velocity increment. Although present chemical fuel rockets are capable of this type of correction, the frequency and magnitude of trajectory corrections is limited in available rockets by the weight of propulsion fuel required.

Improvements in chemical fuels will permit greater corrections to be made for the same weight of the midcourse guidance system.

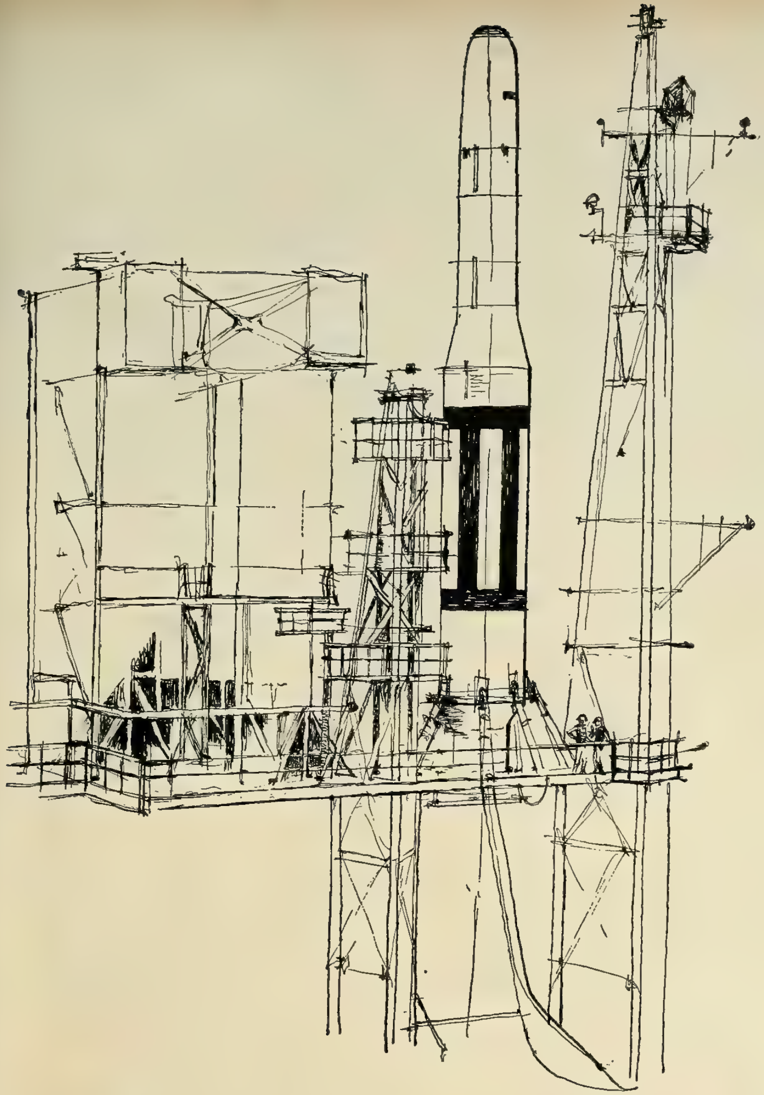
• **Navigation plan**—A simplified block diagram of a space navigation system is shown in Fig. 3. It consists of a celestial tracking system for measuring orbital position, a gyro-stabilized platform for stabilized attitude indication and for precise determination of acceleration during trajectory correction thrust periods, and an orbit computer that determines the actual orbit from the position, acceleration, and time information and computes the correction necessary to achieve an orbit that intersects the destination planet at the proper time. The system shown includes the reaction-thrust means that stabilize the vehicle in attitude and apply the correction thrust as called for by the orbit computer.

Accuracy depends on three factors:

1. Resolution of detection means—The entire electromagnetic spectrum should be considered in obtaining suitable detection means. Visible light may be used with visual or photoelectric sensing. The infrared spectrum may be sensed with suitable detectors. Radio waves, including those generated by the stars and planets themselves, are also a possibility.

2. Sighting mechanism—The mechanism used to align the "telescope" for celestial sighting must be extremely precise and relatively complex.

3. Readout—The electrical readout of the sighting system must use a digital technique. Analog equipment is limited to accuracies in the order of minutes of arc unless extremely complex tech-



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niques are used extensively.

Precision and complexity also are major problems in the orbit computer. This equipment must compute new trajectories that take the vehicle from its present position in space to a new estimate of Venus at arrival time. Hence it must be capable of almost an infinite number of complete orbit computations. It is comparable in complexity to a large, high-speed general purpose digital computer that—somehow—must be made small enough and of a low enough power consumption to be carried and used on a space vehicle.

• **Tracking accuracy**—An approximate determination of celestial tracking angular accuracy requirements may be made by the approach shown in Fig. 4, assuming a flight from Earth to Venus. The following are assumed control system objectives:

1. To insure that the approach to Venus is sufficient to subsequently attain a circular orbit about the planet. For the present purpose, it is assumed the space vehicle must intersect an orbital altitude with an error of less than 10,000 miles.
2. To use minimum fuel.

When the vehicle is near to Earth, the orbit uncertainty resulting from position and velocity measurements creates a large approach error at Venus. When the vehicle is half the distance to Venus, the uncertainty in the vicinity of Venus is much smaller, assuming the same inaccuracies in orbit measurements. At this time, a trajectory correction is made, resulting in a reduced approach error. As the flight progresses, the procedure is repeated every time the distance to go is reduced to one-half of that when the last trajectory correction was made.

In actual flight, corrections would be made whenever significant accuracy could be gained, since fuel is saved by correcting as early as possible.

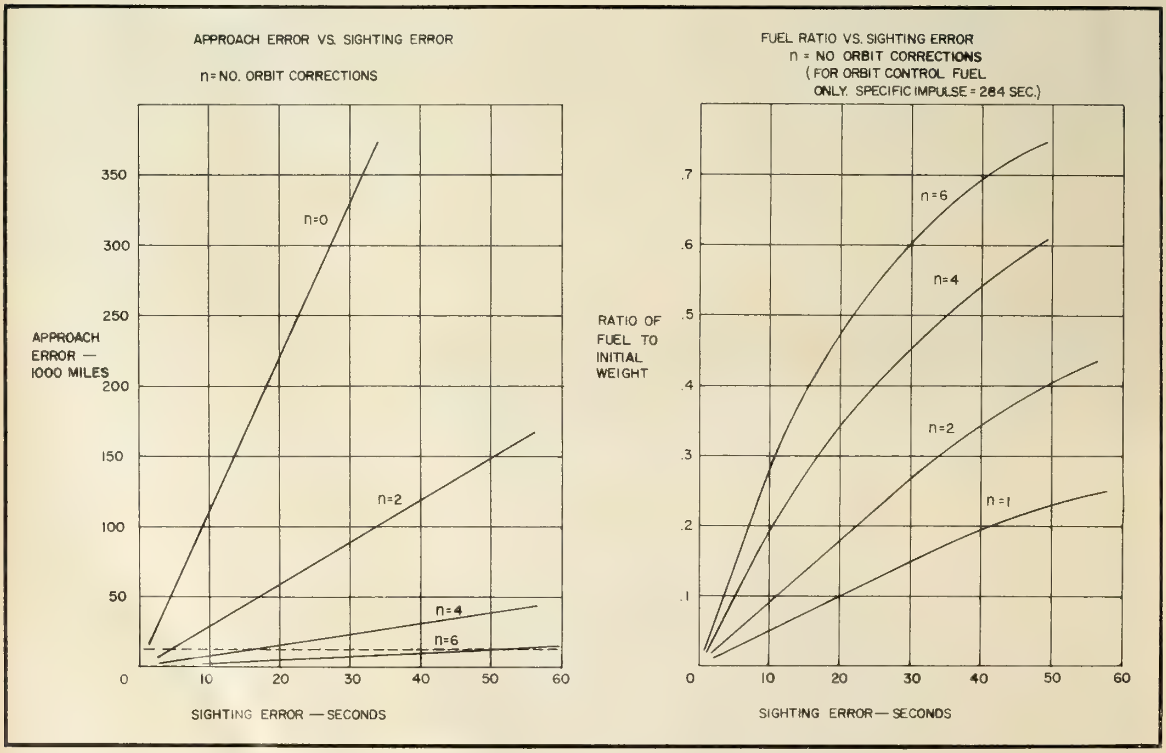
It was assumed that the orbital velocity relative to Earth and Venus was roughly 6 mi/sec., and that position measurements obtained by sun and planet sighting were "averaged" over a one day period to determine velocity.

The variation of approach error with sighting error is shown in Fig. 5. For no trajectory correction (N = O), the sighting accuracy must be less than 1 second of arc to "hit" Venus within 10,000 miles. However, with six trajectory corrections an accuracy of 50 seconds is sufficient. It is also evident that if unlimited corrections can be made (unlimited power), accuracy is no longer important, and the space navigator could "drive" to Venus with only visual contact.

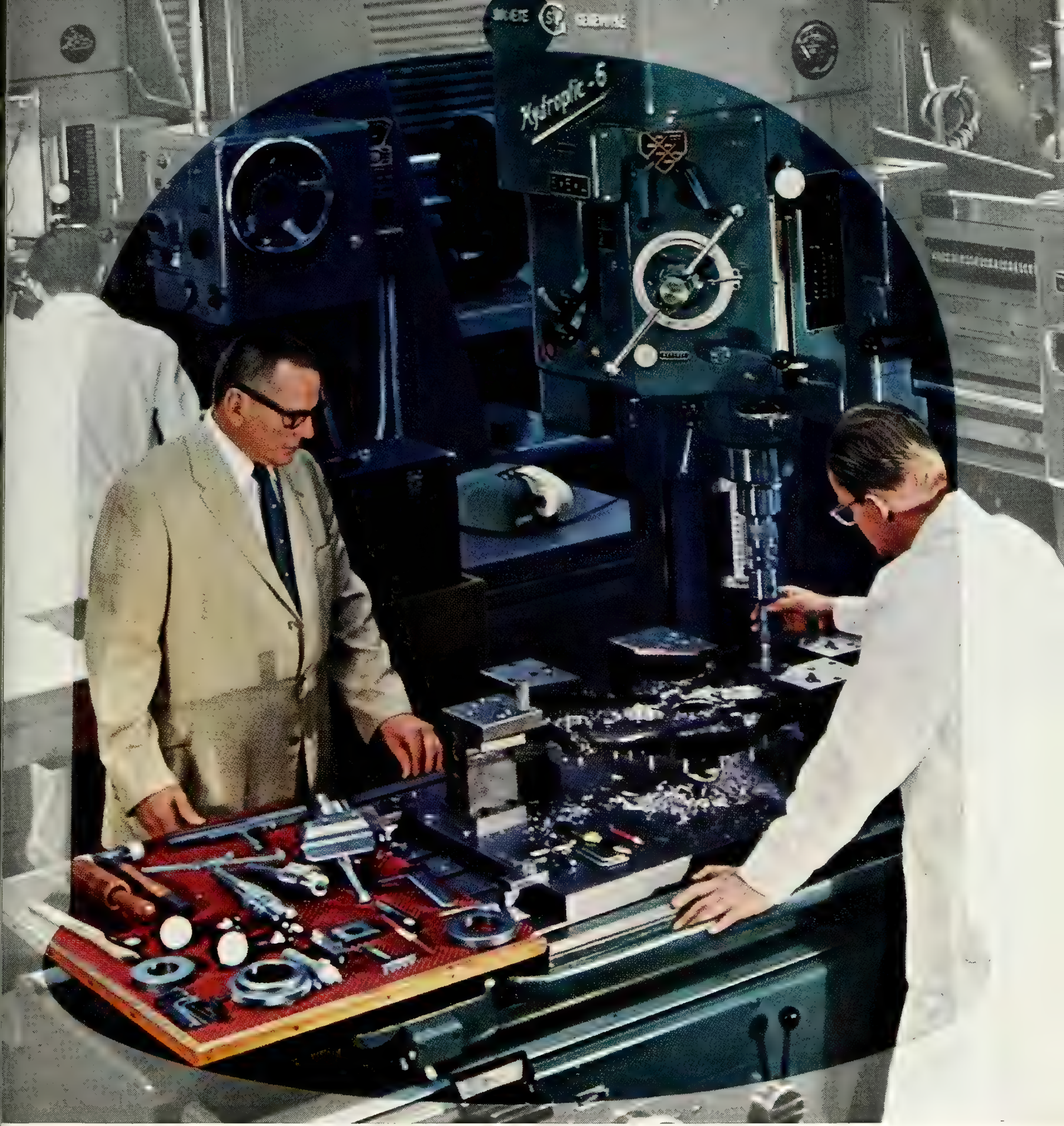
• **Fuel needs**—The ratio of fuel to initial weight for various sighting errors is shown in Fig. 6. The ratios plotted are only for the fuel required for orbital control—the propulsion power for escape from Earth and orbit attainment about Venus is not included. A specific impulse of 284 seconds is assumed.

If a fuel ratio of 0.2 is acceptable, the sighting error must be 7 seconds of arc for the 6 trajectory corrections required for a 10,000-mile approach error. A low fuel ratio is obviously desirable—if we assume an escape fuel ratio of 0.9, a Venus orbit fuel ratio of 0.5, the above fuel ratio amounts to 20% of the payload on only a one-way trip. Comparison of Figs. 5 and 6 demonstrate that the necessity for low fuel weight requires more precise sighting accuracy than that required for low guidance errors:

Therefore, for a fuel ratio of 0.2, and an approach to Venus error of 10,000 miles, the angular accuracy of celestial tracking must be less than 7 seconds of arc for present day propulsion fuels. An increase in the specific impulse of the fuel has an almost direct effect on this requirement. An increase to 1500 seconds, approximately 5 times, permits a sighting accuracy of 30 seconds or roughly 4 times the above requirement.



VARIATION OF APPROACH error with sighting error (Fig. 5). Ratio of fuel to initial weight for sighting errors (Fig. 6).



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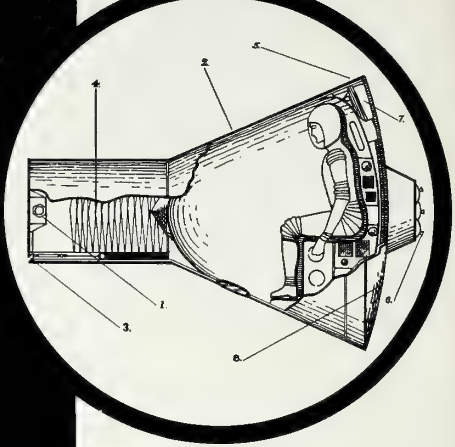

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The How and the Why of Inertial Guidance

While basic principles have been known for many years, solution of some of the problems peculiar to ballistic missiles is only now becoming a reality.

by F. K. Mueller

Inertial guidance is the only near-perfect system yet known for directing the flight of big missiles. Many attempts have been made to outline the real problem and the solutions now being used. But most explanations—deeply oriented in inertial guidance of winged aircraft—have one basic fallacy when applied to ballistic missiles: the stable reference is never self-contained. Rather, it is always assumed in terms of the Schuler Pendulum—a proper device in considering sub- or near-sonic speeds, but completely useless in terms of ballistic velocities.

Because of the increasing interest in inertial guidance of IRBMs and ICBMs, m/r in this issue presents a primer in the subject by one of the world's experts—F. K. Mueller, deputy director of the Guidance and Control Laboratory, Development Operations Division, Army Ballistic Missiles Agency. Readers will remember Mueller's article, "The New Look in Gimbal Systems," in the March, 1958 issue. Gimbal systems like those he described then, together with the principles presented here, were the basis for this country's first operational true inertial guidance system—the guidance and control arrangement on the Redstone.

HUNTSVILLE — Tremendous effort has gone into the development of inertial guidance systems over the past few years to satisfy a basic requirement of ballistic missiles:

Measurements must be made continuously—and directly on the missile—during its flight, in order to guide the missile inertially and make it hit its predetermined target. These measurements—to determine angular orientation and motion of the center of gravity—must be referred to a fixed three-axis coordinate system within the vehicle, where actual conditions are automatically compared to a predetermined flight program. And from these comparisons, necessary signals must be generated to cut off thrust and make corrections in attitude and trajectory.

In theory, the answer is comparatively simple: gyro-stabilized platforms and accelerometers would do the trick. But although the basic principles of inertial guidance were known 25 years ago, the solution of some of the problems peculiar to missiles is only now beginning to emerge.

Very briefly, an inertial guidance system works this way: The stabilized platform provides a fixed coordinate reference system, and also a carrier for the accelerometers. The accelerometers measure components of the linear missile acceleration, in directions previously established by the reference system, thus making it possible to compute missile velocity and distance covered—two basic elements of any navigational problem.

- **Obstacles**—But missiles immediately posed some very special problems. One of these had to do with the gyroscopes that are the basis of the stabilized platform. The precession rate of conventional ball-bearing-mounted gyroscopes can vary from a few to 50 degrees/hour in a matter of minutes. Such a precession rate—in a gyro mounted in a ship or an airplane—is not a particularly serious matter. The relative speed is low enough that the deviation seldom can assume serious proportions, and it can be easily monitored by other devices, including magnetic compasses.

But the enormous acceleration and speed of the missile, and the fact that complicated supervisory devices must be cut out, make it imperative that the gyros in missilery be as nearly frictionless as possible, to reduce the precession possibilities to the barest minimum.

This problem has been brought under control by the development of so-called frictionless bearings—floating either in liquid or under pressure in gas.

Aside from such problems as these, there are numerous environmental conditions to be coped with:

Practical logistic support requires rugged instruments that may be stored for a long time and transported by conventional means without special temperature and humidity. They must require no recalibrations, be easy to check out and have easily-exchanged components. These are not features normally associated with high-accuracy instruments.

To meet these needs, rugged and symmetrical designs have been made with materials carefully selected in regard to dimensional stability, thermal expansion, low creep and corrosion.

Finally, the flight itself presents many problems: The instruments are subject to high-thrust acceleration—changing in magnitude, and partially in direction—and to vibration. While the acceleration forces are known, those of vibration are not—the designer must anticipate them as best he can.

- **Start of progress**—Designers of a missile component must understand the various phases of the flight of their bird, before working out details of the component.

Careful plotting of the trajectory of a ballistic missile is illustrated in the accompanying Fig. 1, tracing the action from launching point through thrust cut-off, free flight and return to the atmosphere—and the target. During the propelled phase, acceleration increases, and direction changes gradually; during free-flight, the missile and

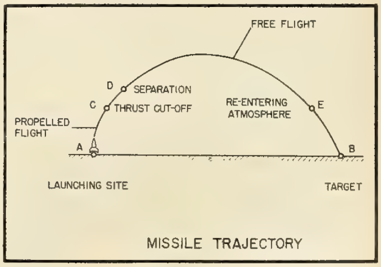
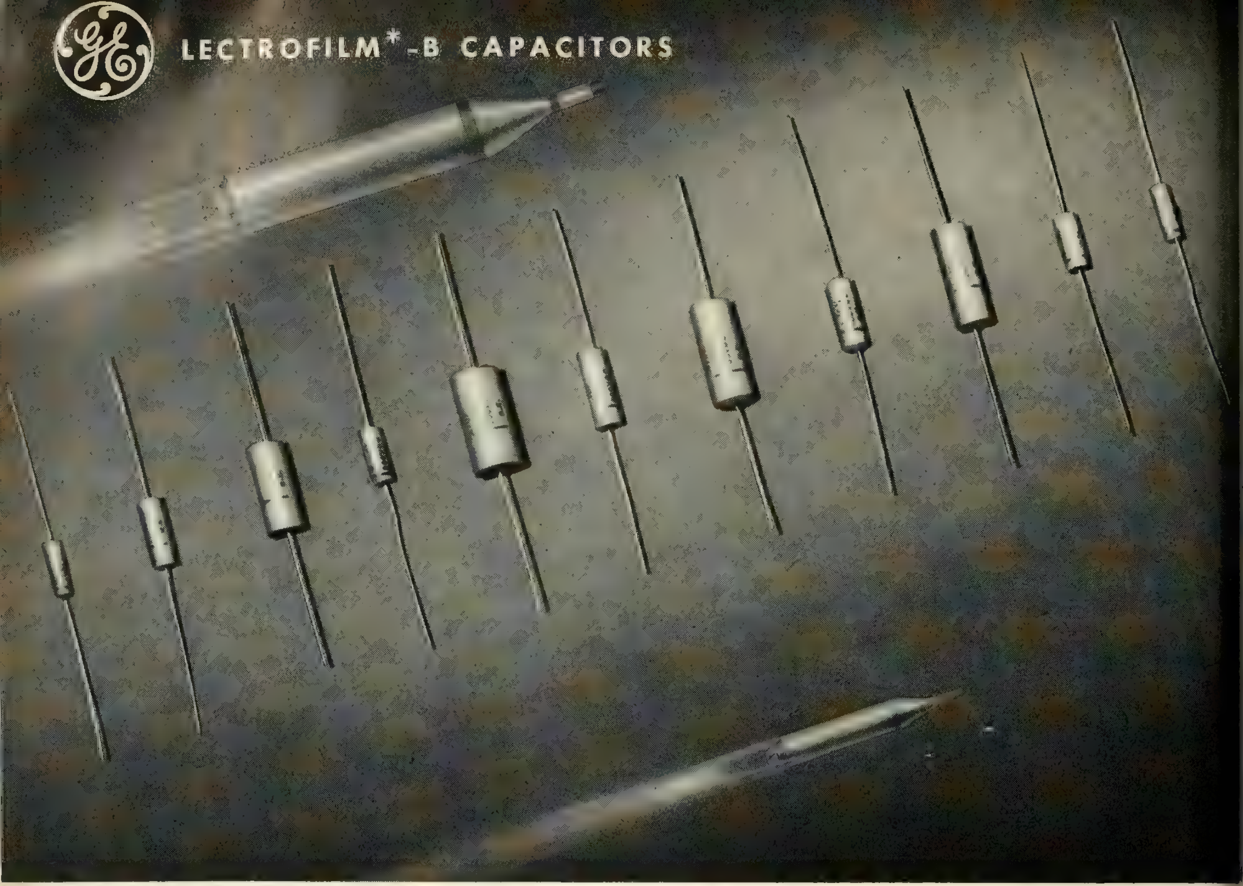


Figure 1.



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its components are subject only to the forces of gravity, and in the final stage, the missile slows down.

During these stages, various means may be used to control the missile and insure its arrival on target: air vanes or swivelling of the motor during propulsion; jets, during the free-flight period; air vanes after re-entry into the atmosphere.

In all cases, sufficient data must be stored in the missile's inertial control system so that proper measures are taken to control the flight to the target.

In detail, here is how these control systems work:

- **Stabilized platform**—The stabilized platform establishes a space-fixed (star-fixed) reference coordinate system. A three-axis gimbal arrangement, supporting the stabilized part, allows for angular motions of the missile. The missile attitude angles are measured on the gimbal rings.

Predetermined tilt programs are introduced on the gimbal system against the stabilized part. Accelerometers are mounted on the stabilized part with their measuring directions suitably oriented to the space-fixed reference coordinate system.

The platform is stabilized in the desired fixed angular position by use of the stabilizing power of the gyros and their precession, in connection with servo systems. The deviation of the stabilizer coordinates from the initially established orientation is called the drift.

Since environmental conditions of a flying missile do not allow supervision of drift, improvement of the drift rate performance for guided missiles is a major challenge confronting the inertial guidance design engineer.

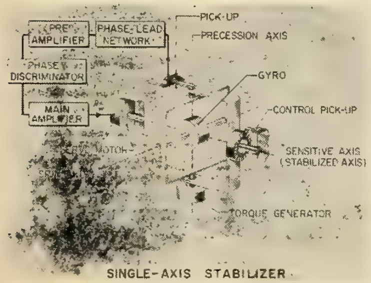

Figure 2.

Fig. 2 shows, in principle, the arrangement of a single-axis gyro stabilization. In spite of the actual three axes, the configuration is considered a one-axis gyroscope because only one axis is employed for stabilization. The associated internal servo loop consists of a servo pick-up, a phase lead network, a pre-amplifier, a phase discriminator, a main amplifier, and a servo motor. The accuracy of such an instrument is mainly restricted by the friction and other disturbing torques about the precession axis.

A complete stabilized platform combines three mutually perpendicular stabilization axes in one gimbal system, and employs for each axis a stabilization arrangement as described for Fig. 2.

To save weight and space, the stabilization axes are established by an internal gimbal system, acting as a universal joint.

Since the accuracy of a gyro is largely governed by the friction on its precession axis, a great effort has been made to develop a frictionless bearing.

- **Frictionless bearings**—In the gyroscopic devices of guidance systems, the precession axes of the gyros are suspended by frictionless bearings. Ball bearings, as they are commonly applied in traditional aircraft instruments, would produce drift rates intolerable for missile guidance.

Very early in the development of the frictionless bearing, this program branched off in two different approaches: one developed the floating bearing; the other, the pressurized bearing. (There are also combinations of these two.)

Both programs progressed so that the performance of the gyros is no longer determined by friction, but by other trouble sources.

One type of the pressurized bearing is the so called Air Bearing. It uses air or gas as a carrying medium.

In an air-bearing device, the inner or floating part is separated from the outer part or the bearing case by a thin film of air.

Compressed air enters the air gap between inner and outer sections through the air inlet, air chambers, and distribution holes, and finally escapes through the air outlets. The diameter of the distribution holes is a few thousandths of an inch, the thickness of the air film about 1.5 thousandths of an inch. Required tolerances on floating part and bearing case are well within the limits for production of precision instruments.

The fact that mechanical contact between inner and outer sections is prevented eliminates coulomb friction. The viscous damping around the air-bearing axis is negligible because of the low values of the viscosity and the angular velocity present during operation.

Carrying capability of the bearing is based on the differential pressure produced by small displacements of the floating part. A characteristic curve of the displacement over the acceleration in g's is given in Fig. 3.

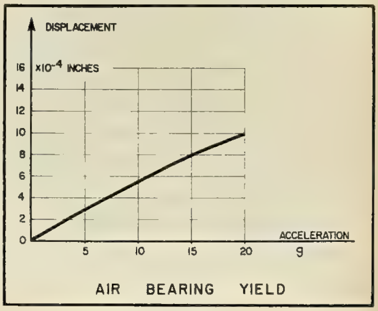

Figure 3.

Because of the elastic air gap, the bearing has a natural frequency on the order of several hundred cycles per second. The inherent damping of these linear oscillations is relatively high and assures stability. Vibrational frequencies of the missile in the neighborhood of the natural frequency of the bearing are already attenuated by the supporting structure.

Basically, the floating gyro is somewhat similar to the air-bearing type. The gyro motor is located in a can. The density of the complete can corresponds to that of the liquid. Therefore, the can or inner part floats in the liquid.

Since the liquid is not pressurized, additional pinion bearings are provided to maintain axial alignment. Although the liquid film is much thicker than an air film, there is considerable viscous damping because of the relatively high viscosity of the liquid.

But even gyros supported by frictionless bearings have some low-level disturbance torques. They can be divided into two groups:

1) Torques inherent in the bearing. Frictionless bearings are never ideal and have some torques due to small imperfections. However, these torques can be kept small enough to be of minor importance.

2) Torques caused by the shift of the center of gravity of the floating part. Because they are sensitive to acceleration, such torques are the major problem for gyros in guided missiles. Dimensional stability under flight condition and isoelasticity of the floating part determine the accuracy of the gyro.

All disturbing torques must be kept within moderately small limits for both types of frictionless bearings. Maximum allowable values depend on accuracy requirements and the value of the angular momentum of the gyro.

While disturbance torques of con-

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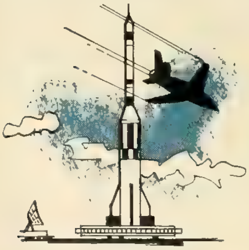

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ventional gyros are expressed in centimeter grams, a unit about a thousand times smaller—the centimeter dyne—is used for frictionless bearings.

• **Gyromotor**—In systems based on frictionless bearings, the shift of the center of gravity or unbalance of the floating part becomes the most important reason for drift. It is caused by dimensional changes of the can and gyro support structure, and by relative displacements of parts making up the gyro motor itself.

The can and the supporting structure should be as sturdy and solid as possible in order to minimize deformations. Air-bearing gyros allow high overall density for the floating part; this gives the designer a free hand in choosing dimensions and materials.

The most critical item is the gyro motor itself, located inside the floating can. Any electrically-driven gyro motor is built up of a number of different materials: bronze or stainless steel for the rotor, silicon steel for the stator, steel for the axle, paper and lacquers for insulation, and copper for motor windings.

The temperature coefficients of expansion of these materials vary over a wide range, so that heating and cooling cycles create slight relative motions of the different parts. It is very unlikely that after such temperature cycles the relative position of parts will correspond exactly to the initial one.

Thus the heat generated in the motor will cause a shift of center of gravity, resulting in a disturbing torque subject to acceleration. To avoid unbalanced effects of this nature as much as possible, the gyro is built symmetrical about its equatorial plane. (See Fig. 4.)

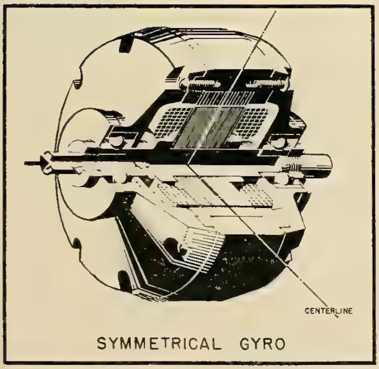


Figure 4.

This kind of gyro motor is of the hysteresis synchronous type, requiring no windings and no electrical connections on the rotating element. Other features are low power consumption (to keep the temperature differences low when in operating condition), close temperature control of the surrounding medium, and stabilization of heat flow by exact control of power consumption and frequency.

Extreme care must be taken to design all the other parts—such as end-bells, shafts, and inner parts—for high rigidity and isoelastic deformation. Disturbance torques caused by unequal elastic deformations depend on the square of acceleration.

• **Drift**—All disturbances occurring in the frictionless bearing, in the can, in the gyro support, and in the gyro motor, produce torques around the precession axis of the gyroscope, and thus cause drift. The three modes are:

a) Constant torques, independent of acceleration.

b) Torques depending on magnitude and direction of acceleration.

c) Torques depending on the square of acceleration and its direction.

Torques dependent on square of acceleration can produce considerable drift rates. They are described by the equation:

$$T = m^2 g^2 Y \,.\, \left(\frac{x}{y} - 1 \right) \,.\, \sin 2\, a;$$

where m = mass, g = acceleration, x and y = yield rates in direction of the main axes, and a = angle between the direction of acceleration and the direction of a main axis.

The g^2 term makes the gyro also susceptible to vibrational accelerations. Since vibrations occur in any direction, angle "a" can be 45°. This means that maximum vibrational torques must be considered. Actually, the drift caused by such vibrational torques can easily exceed those caused by linear acceleration. With respect to thrust acceleration, the angle "a" can be kept small by particular arrangement of the gyros on the stabilized platform.

For missile guidance, another type of supervision was developed: "stellar supervision, or star tracker." Such a star tracker, mounted on the stabilized platform and relying on the position of a fixed-star, indicates the gyro drift and provides proper correction signals.

Even in this case, the requirements on the gyro drift are still very high. The missile has to be guided to considerable altitudes, and the selected star must still be within the restricted aperture of the star tracker after the elapsed flight time. It is obvious that stellar supervision, with all its inherent complications, pays off only for long-range missiles with a long guided-flight phase.

• **Servo loops**—gyro stabilizers require servo motors and associated electrical servo loops to support their gyros and maintain their position. They operate this way: A gyro transforms any torque about its stabilizing axis in an angular velocity about its precession axis. A pick-up on this axis gives an output proportional to the precession angle, which means that this pick-up delivers an integrated value which lags with reference to the torque input. Through correcting networks and amplifiers, the output controls a servo motor on the stabilizing axis to compensate the original disturbance torque.

Considering transients, the networks have to compensate for the phase shift caused by the integrating feature of the gyro and for any inherent time constants. They also have to provide enough phase shift for damping.

Where a gyro can be used with a relatively large angular momentum, it will provide direct stabilizing power to the platform, taking care of transient torques. The servo motor deals mainly with the steady-state torques. In such a system, gain-and-response requirements on the servo loops are not too stringent.

But gyros with relatively small angular momentum require higher gain and much faster response in servo loops and servo motors. While the large gyro provides brain and muscles, the small one provides brain only, and stabilization depends entirely on its servo system. For weight, space, and simplicity, a good compromise must be found.

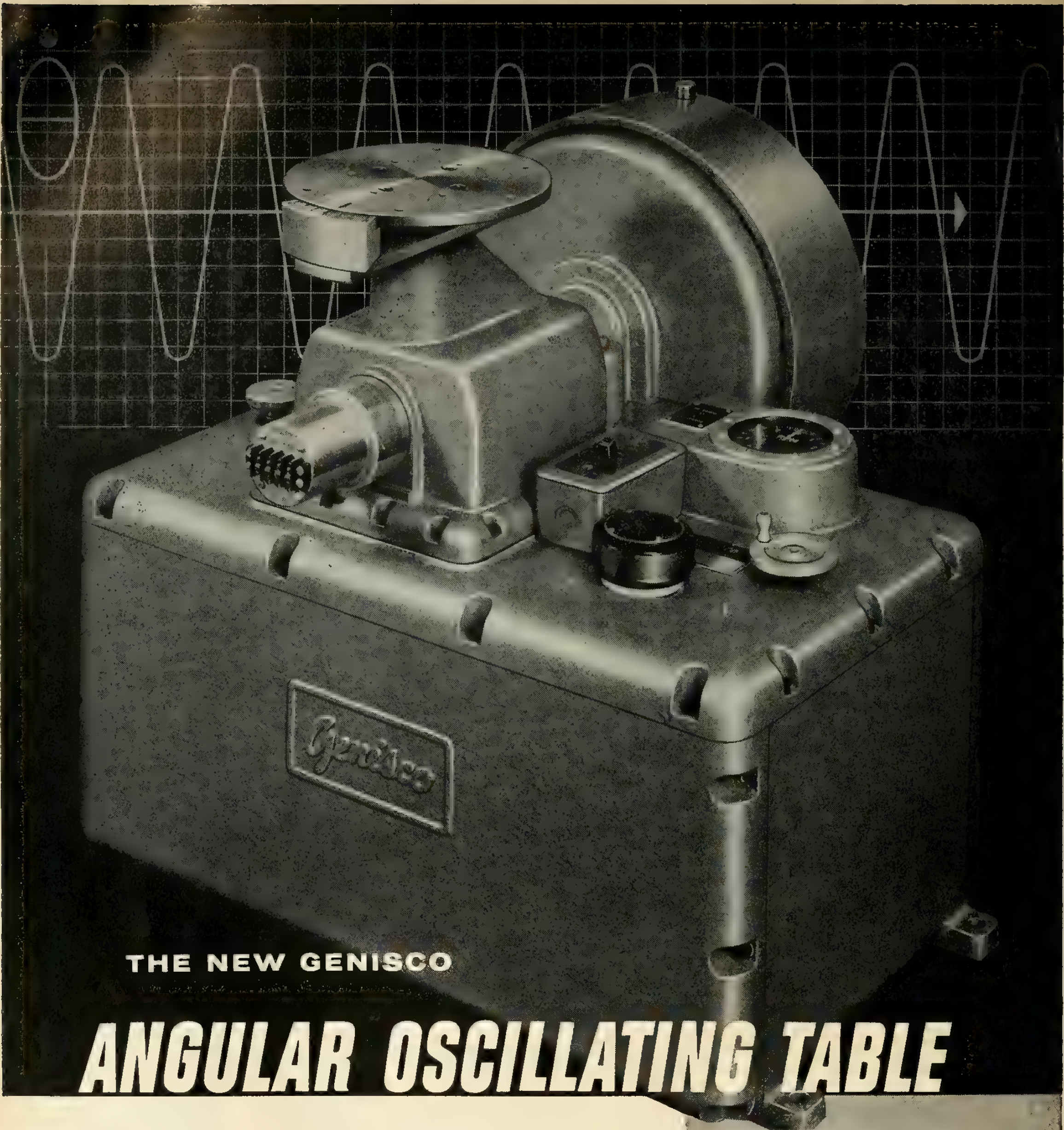
The type, as well as the relative size, of the stabilizing gyro influences the servo loop. Liquid floating gyros provide a considerable amount of viscous damping on the precession axis, easing the servo loop stability problem by omitting the torqueless precession axis.

Air-bearing gyros, for all practical purposes, do not have a viscous damping on the precession axis. Hence the servo loop must provide all the damping. Incorporation of the first and second derivative of the angular servo pick-up signal is required.

To maintain extreme reliability of the servo loops under pre-flight and flight conditions, transistor or magnetic amplifiers should be applied wherever possible.

• **Accelerometers**—Another major component in inertial guidance is the accelerometer. There are two principal types in development: the reaction type and the gyro type. Both use the inertia of an unbalanced mass to create a torque proportional to acceleration.

In the reaction type, the unbalance torque is compensated by an electrical torquer. The current required by this



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Accuracy:
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Frequency Indication – within 1% with tachometer; within 0.1% with stroboscope.

Payload Capacity: 100 lb. deadweight; 750 lb.-in. under dynamic conditions. Protected against dynamic overload by replaceable shear pins.

Vibration Isolation:
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Platform Diameter: 8".

Approx. Weight: 400 lb.

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torquer is proportional to the torque produced by the unbalance. Its value has to be measured. Velocity and distance may be obtained by integrating this value in a computer—once and twice, respectively.

There is a special type of reaction accelerometer, usually known as the double integrating accelerometer. A frictionless bearing supports a can with a pendulous weight and a position pick-up. A motor with a high-inertia rotor is mounted inside the floating part with its axis parallel to the axis of the frictionless bearing.

An acceleration perpendicular to this bearing, and to the pendulous weight, results in a torque and in an output of the position pick-up. This output controls the speed of the motor in such a way that the reaction torque compensates the acceleration torque.

Therefore, the instantaneous angular velocity of the rotor corresponds to the first integral of the acting missile acceleration over the time—in other words, to the velocity of the missile. The angular position of the rotor at any given moment corresponds to the second integral of the missile acceleration over the time—the distance covered by the missile.

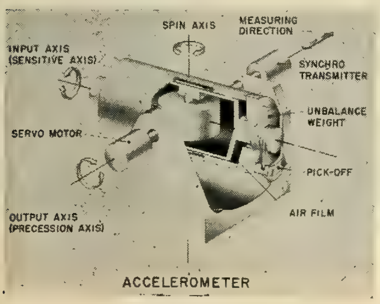


Figure 5.

In the gyro type accelerometer, shown in Fig. 5, the unbalance weight is mounted on the input axis of a gyro. It will produce a torque about this axis proportional to the acceleration. This torque in turn will produce a precession rate about the output axis, which is also proportional to the acceleration of the missile in the measuring direction.

The angle through which the precession axis turns is the integral of the rate of turning over a certain time. It corresponds to the velocity of the missile. Only one additional integration in a separate computer is necessary to obtain the distance covered by the missile.

Friction and other disturbing torques about the input axis of any accelerometer must be kept at a very low level. They sum up with the effective unbalance torque and therefore introduce an error. To meet the accuracy requirements of guided missiles, it is mandatory to keep the ratio between effective unbalance torque and disturbance torque high.

This means that a frictionless bearing must be applied, and extreme care must be taken to hold any other disturbing torques small. The gyro type accelerometer allows a relatively large effective unbalance torque, since there is no limitation by a possible reaction torque.

A particular requirement for an accurate gyro accelerometer is that all axes be initially aligned perpendicular and remain so within a few seconds of arc. This is achieved by precise machining and calibrating.

The instrument requires an internal servo loop like any other gyroscope. This servo loop must be very rigid to hold the alignment of the unbalance weight in the measuring direction, and very well damped to restrain the effects of missile vibrations transmitted through the stabilized platform to the accelerometer.

The a-c supply frequency for the gyro drive has to be regulated very accurately since the angular momentum of the gyro is directly proportional to the frequency, and the angular momentum is a constant in the computation of velocity and distance. Thus a special frequency governor is used to provide the required accurate frequency.

- **Integrators**—Depending on the overall guidance scheme and the type of accelerometers used, one or two integrations must be performed to acquire velocity and distance covered by the missile. These integrations can be accomplished by either electrical or mechanical means.

Electrical integrations call for computers with analog or digital output. The mechanical integrations most commonly feature a ball and disk integrator. Weight and space considerations normally prevent mounting the integrator directly on the stabilized platform. They are placed separately in the missile instrument compartment with temperature control and vibration damping.

A transmitter system of high accuracy is required to connect accelerometer and integrator. The type of transmitter depends also on an accelerometer and integrator system. In the case of the integrating gyro type accelerometer, and a ball and disk integrator, a synchro transmitter and receiver system is used.

Fig. 6 shows the principle of the ball and disk integrator in connection with an integrating accelerometer. On the left is the accelerometer, with the synchro transmitter on the upper end of the output axis. The transmitter is connected to the synchro receiver by a highly accurate, responsive, and well damped servo system.

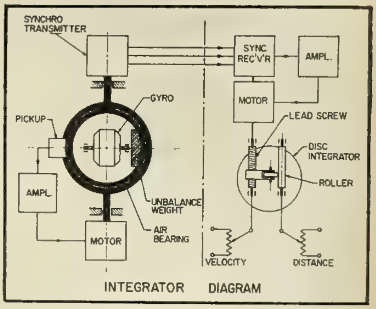


Figure 6.

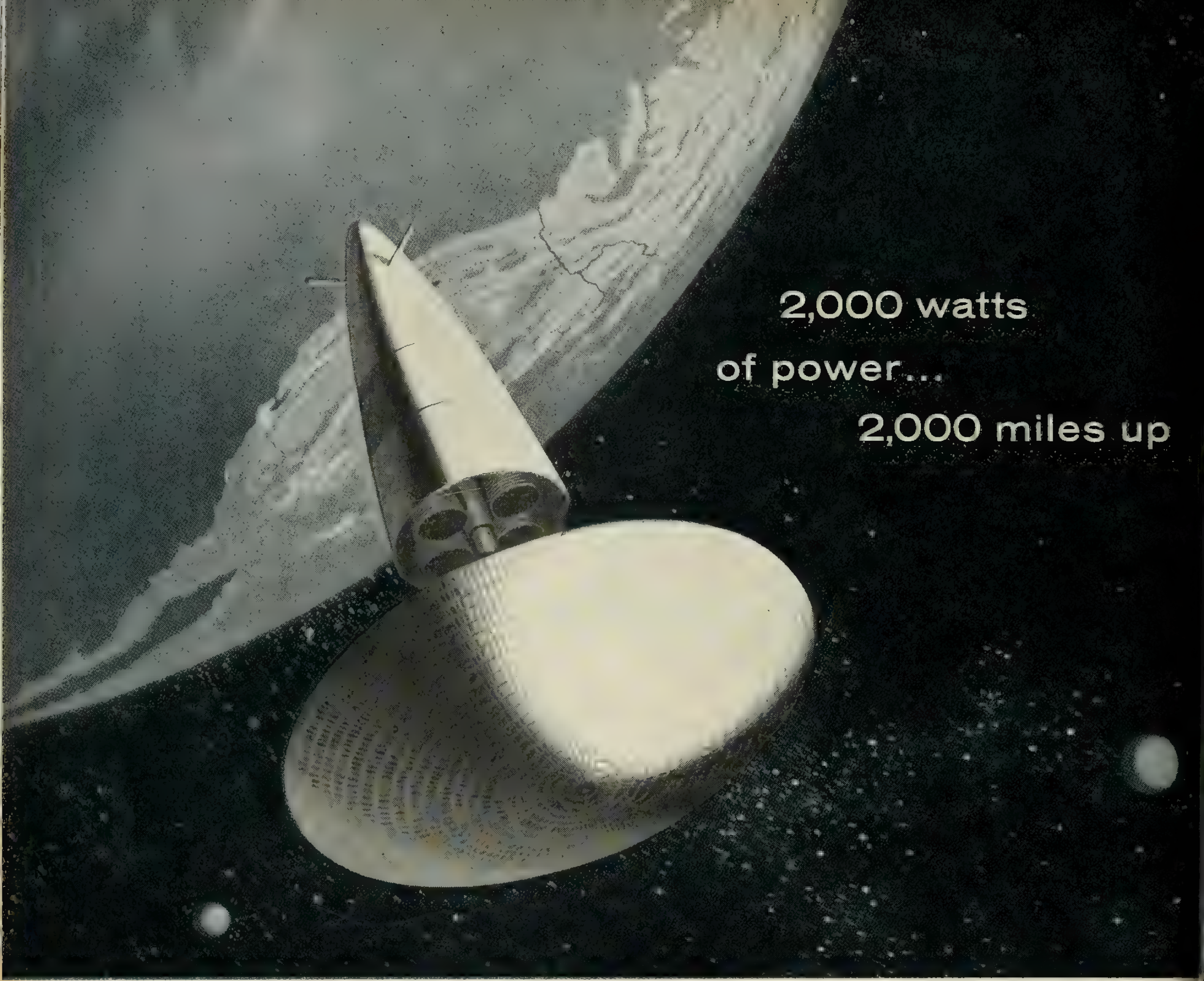
The servo system repeats the angular position of the output axis of the accelerometer. It introduces this value into the ball and disk integrator with a clutch and a lead screw as a linear position of the ball from the center of the disk.

In the accompanying picture, the ball is shown as a small wheel, to indicate its rotational axis. The disk rotates with a highly accurate constant velocity driven by a synchronous motor. The bill, pressed by its carriage and a spring against the disk, rotates due to friction. Its angular velocity is a function of its distance from the center of the disk.

The rotational angle of the ball corresponds to the integral of its angular velocity. If input on the lead screw corresponds to the velocity of the missile, the output angle of the ball represents the distance covered by the missile. The rotational angle of the ball is picked up by a roller which covers the length of the lead screw. The velocity of the missile and the distance covered are finally picked up as electrical voltages on potentiometers. These voltages are used in the control computer to compute the thrust cut-off point and to guide the missile along the flight path.

Considerable development work has been done on such integrators. They have been used in computers for Navy ships and anti-aircraft equipment. But a number of modifications had to be made to develop a unit which would perform accurately under missile accelerations, vibrations and temperature conditions.

- **Alignment**—The inertial guidance system must be set with respect to a predetermined reference system, considering the exact relationship of launch and target points. Final accuracy of the missile cannot be better than the initial alignment of the



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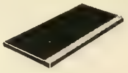

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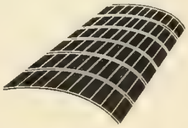

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inertial guidance system.

Because launching point and target point are earth-fixed, it is essential to keep the inertial system earth-fixed up to the moment of launch. But the gyro-stabilized platform is space-fixed by nature. Hence, during the pre-launch time, the gyros have to be influenced in a manner that will maintain their position fixed relative to the rotating earth.

At the moment of launch, the inertial earth-fixed system is converted into a space-fixed system. Because all trajectory calculations are made for the space-fixed system, no corrections need be fed to the gyros during the flight—a great aid to accuracy.

The inertial reference systems must also have a certain relationship to the missile coordinate system. This can be done, within a few tenths of one degree, during assembly of the missile, using a special adjustable frame. It is difficult to obtain a higher accuracy, because of the flexibility of the missile structure and the exact determination of the coordinate system of the missile structure itself.

Since initial alignment of the guidance system requires much higher accuracy, alignment by setting the missile on the launching table with the required accuracy appears impractical and probably impossible. Therefore, the inertial system has to be aligned independently of the missile structure.

For the horizontal axes, sensitive plumb-line detectors or accelerometers can be applied to torque the appropriate gyro with amplifiers and torque generators. A special plumb-line detector has been developed which is sufficiently sensitive and has a very high degree of zero point stability. Perfect symmetry of design and use of an air bearing made this achievement possible.

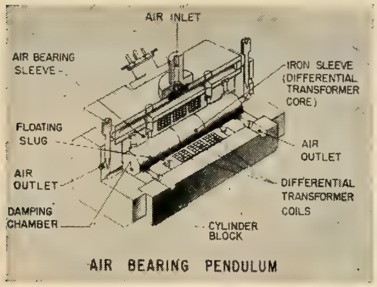
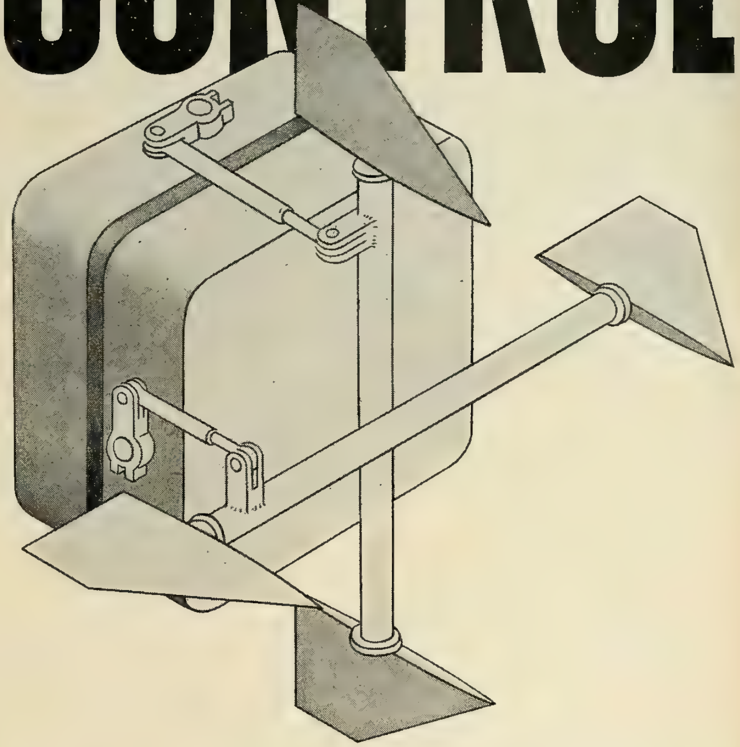


Figure 7.

Fig. 7 shows a cut view of this device, the air bearing pendulum. It consists mainly of the bearing support, the floating slug, the differential transformer and the damping chambers.

Fig. 8 shows transfer functions of the various elements required for alignment about one horizontal axis,



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while inertia of the pendulum and inertia and friction about the stabilizer axes are neglected.

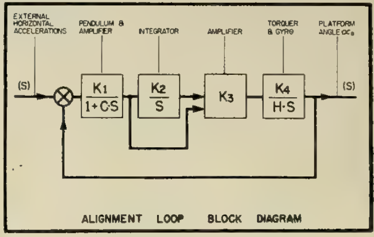

Figure 8.

Alignment of the inertial reference system with respect to firing direction must be equally accurate. This is normally done by optical means—human observation and correction or automatic scanning devices. It requires optical observation of reflectors mounted on the stabilized platform, or on the platform mounting frame with which the platform is initially aligned.

The loop and its transfer functions are similar to those described above for the horizontal axes. It also includes the integrator for the earth rotation bias.

At the moment of launching, the plumb-line detectors and course setting device are de-energized and the inertial reference system becomes a completely independent space-fixed system. The gyros take over their elementary task—to resist angular motions under the most crucial conditions caused by missile vibrations and accelerations.

• **Testing**—New components must be extensively tested before they can be used for active missile guidance.

Whenever possible, an experimental missile is used and the component rides along as a passenger. During flight, performance values are measured and telemetered for evaluation. In other cases, sled tests are performed simulating expected flight conditions. Again, the critical characteristics are telemetered.

Both sled tests and passenger flight tests are limited to more or less functional evaluations, making it necessary to perform the accuracy tests in the laboratory.

The novelty of the instruments and their range of accuracy requires newly-developed test devices. In some cases the readout has to rely on precision optical instruments. A typical example is the stabilizer test stand.

This stand is used to determine the drift rate of the three-axes stabilized platform. It features a sidereal time axis aligned parallel to the rotational axis of the earth and driven with side-

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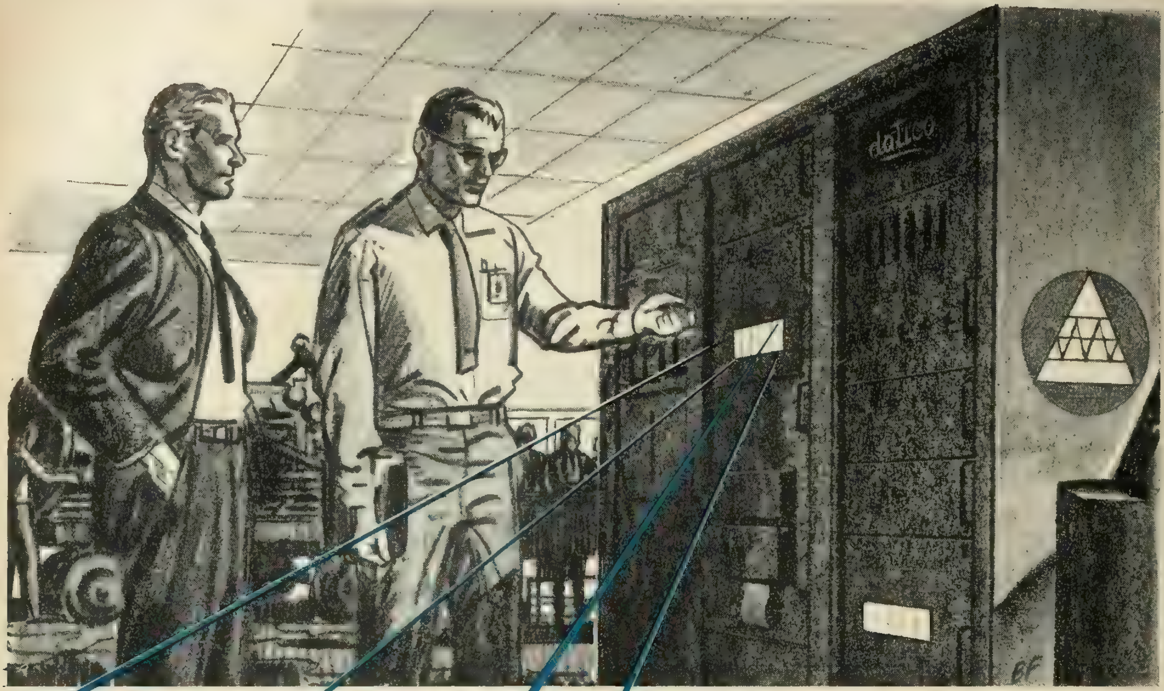

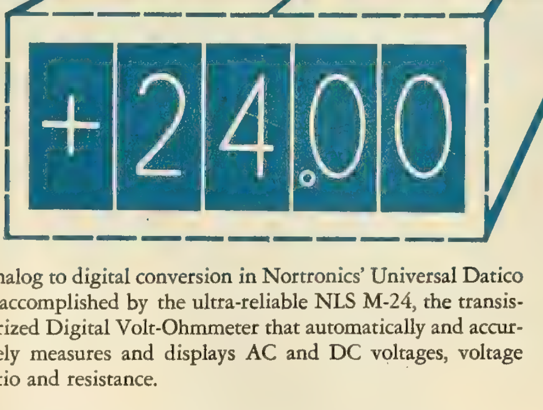

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The tape also establishes the go-no-go limits for comparison with the M-24's digital output. It then directs the system to the next channel to be measured.

Operation of the NLS M-24 in this system is completely automatic . . . the instrument is remotely operable, does not require zero setting, and is extremely stable over very long time periods. Over-all system speed is not compromised by analog to digital conversion time, the M-24 making each measurement in just 330 milliseconds.

The NLS M-24 meets the unusually great reliability demanded of automatic test equipment for modern electronic weapons systems. This reliability is assured by transistors, mercury-wetted contact relays (rated at 10 billion measurements), advanced circuit design, and thorough production and field testing.

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real angular velocity.

During the test, the whole system, stabilized platform and readout collimators revolve with sidereal velocity compensating for earth rotation. The collimators therefore remain in a space-fixed position and allow by means of reflecting mirrors, low drift measurements of the space-fixed gyro platform.

During such tests, missile oscillations can be simulated by uncaging the incorporated gimbal axes of the test stand and introducing corresponding angular motions.

- **Outlook**—The present status of development is evidence of tremendous progress. In fact, the systems of today exceed in many ways what was hoped for when this particular development began.

It can be said that inertial guidance has so far kept in pace with overall missile development. But the missiles, satellites and re-entry vehicles of tomorrow are presenting new problems.

First, there is the task of drastic miniaturization. Guidance components must be smaller and lighter. They also should consume considerably less power and perform with even greater accuracy and reliability. New principles may have to be applied to reach these goals.

The new vehicles will be subject to extraordinary environmental conditions—some of which can be produced in test laboratories for very short periods only, or not at all. Obviously, new test equipment must be developed.

It adds up to another tremendous challenge for the guidance design engineer.

Technician Shortage Is Due to Become Worse

WASHINGTON—At the beginning of what might be called the "scientific revolution," the United States finds itself dangerously short of trained technicians, engineers and scientists.

This is the assessment of the President's Committee on Scientists and Engineers, established in 1956, which recently submitted its final report.

And the committee is fearful that the present shortage of trained manpower will get worse.

The Committee points to a drop in 1958 enrollments at engineering schools, and warns that in 1965 the "lean generation" resulting from lower birth rates in the depression and war periods will provide the country's labor force with fewer men in the 25 to 34 age group.

To correct the shortage, the committee of educators, scientists, labor union, business and government representatives urged the White House to

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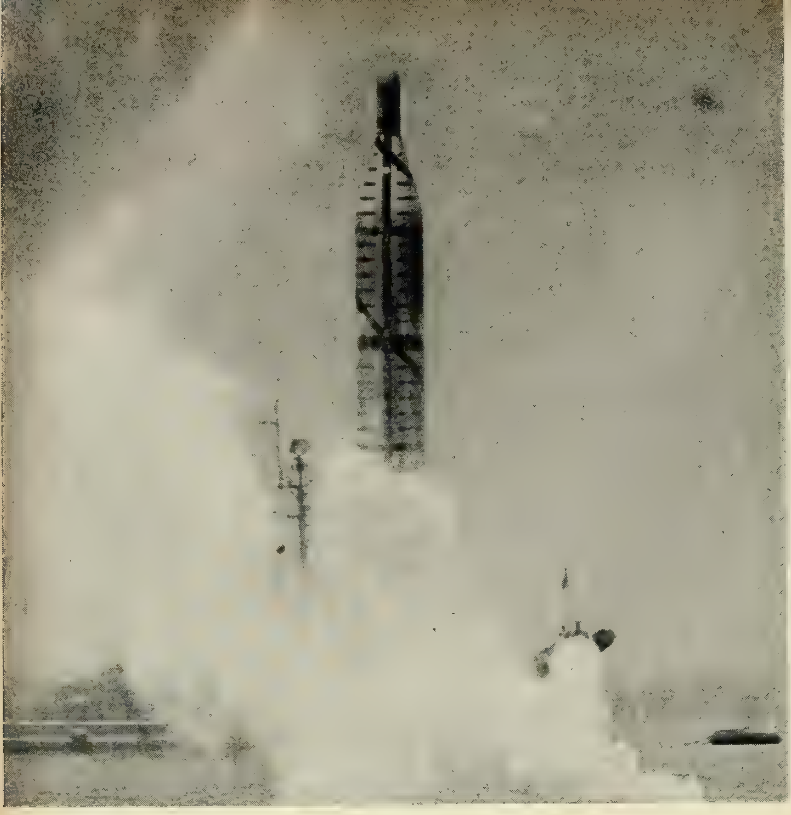
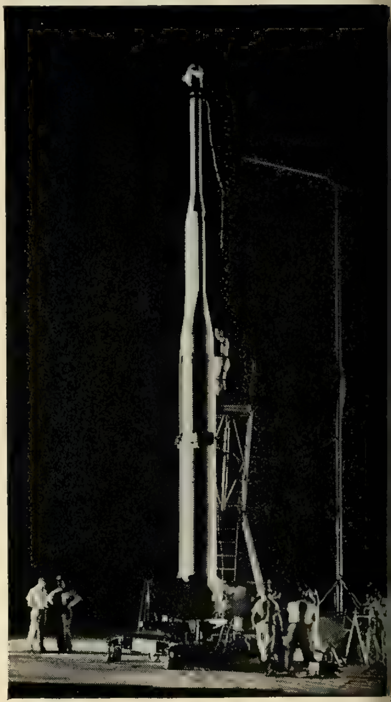


(left) Pop-up test of Navy Polaris IRBM.

(below) Nation's first successful re-entry tests were conducted with the Lockheed X-17.



EXPANDING THE FRONTIERS OF SPACE TECHNOLOGY

...Structures and Design

Design is a challenging and growing field at Lockheed dealing with varying phases of mechanical, electrical and structural problems.

Some of the most difficult structure problems in the missile industry were successfully met by Lockheed design engineers for the Navy Polaris IRBM, where the unique launching environment—water—aggravates the normal critical missile requirements of strength minus weight.

Major emphasis in structures concerns the design of re-entry bodies, thrust termination, and underwater launching devices. Other significant work has been accomplished in the mechanical design of vehicle frames, flight controls, hydraulic, ignition and separation systems; and in the electrical design of equipment for test, check out, arming and fusing, guidance, and telemetry.

As systems manager for such major, long-term projects as the Navy Polaris IRBM; Army Kingfisher and Air Force Q-5 and X-7 and other important programs, Lockheed engineers and scientists face a double challenge — to improve existing designs and devise solutions to new problems.

Scientists and engineers of outstanding talent and inquiring mind are invited to join us in the nation's most interesting and challenging basic research and development programs. Write: Research and Development Staff, Dept. B-29, 962 W. El Camino Real, Sunnyvale, California.

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Lockheed / MISSILES AND SPACE DIVISION

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take direct responsibility for coordinating and stimulating efforts by public and private groups to meet the problem.

The committee reported that *Sputnik 1* woke the American people up to the nation's scientific needs. What is now needed, according to the Committee, is a "follow-through" by Congress and the Administration.

Convair Investigates Environmental Tolerances

SAN DIEGO—Human tolerance of extreme environments is under continuing investigation at Convair-San Diego. Principal projects involve reaction to high acceleration forces and toleration of temperature extremes as related to special protective garments.

The acceleration study is almost completed. Primary purpose has been to prove a theory held by Dr. R. C. Armstrong, space and radiation medicine group, that increasing breathing air supply pressure can decrease human stresses produced by exposure to high acceleration forces. Study results have substantiated the theory, Dr. Armstrong says, and the data will serve as guides for space vehicle environments.

"Application of the principles can significantly affect the ability of space pilots to tolerate the combined stresses of space flights and thus increase the safety of the man and his mission," he predicted.

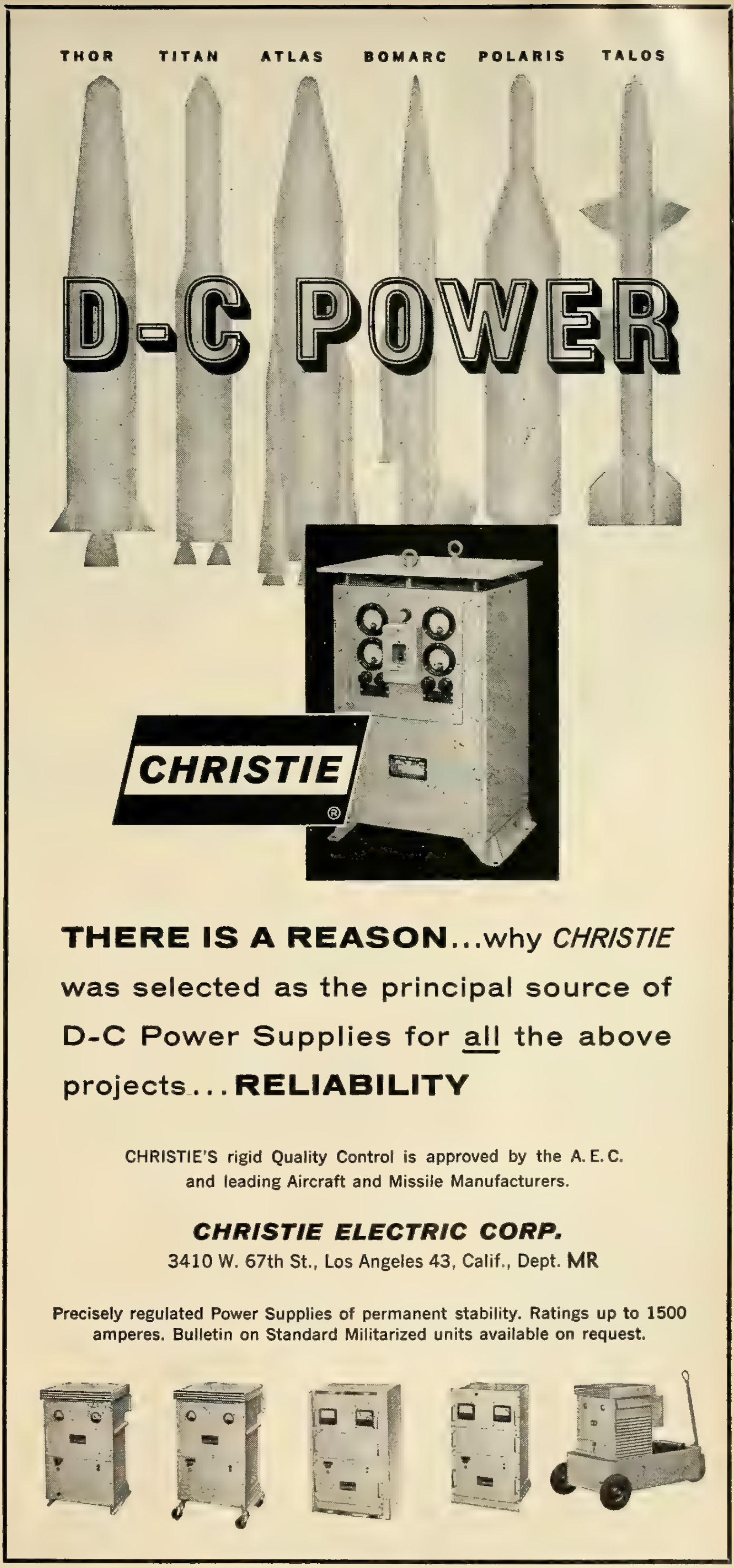
All acceleration experiments were conducted at the University of Southern California's human centrifuge laboratory.

The second program, a study of human ability under temperature extremes both with and without protective garments, is being conducted at Convair's dynamic laboratory under direction of Dr. Armstrong and Dr. E. G. Aiken of the human factors section.

Physical and psychological reactions to simulated re-entry temperatures or heat generated by Mach 5 aircraft flights are being studied in a special heat chamber. Subjects are Convair volunteers.

Air temperature is increased in the chamber from 80°F to 200°F in 19½ minutes—held at 200° for six minutes—then returned to 80° for another 19½ minutes. Cold air (–13°F) is blown into the chamber to reduce air temperatures during the cycle. Chamber temperature itself is maintained at 285°F by a 40,000-watt infrared light bank.

During the high-heat cycle, cool air is used to ventilate a special pressure suit under study which is designed to maintain a normal body temperature of 98.6°F. The "pilot" is supplied with his own filtered and refrigerated air, piped



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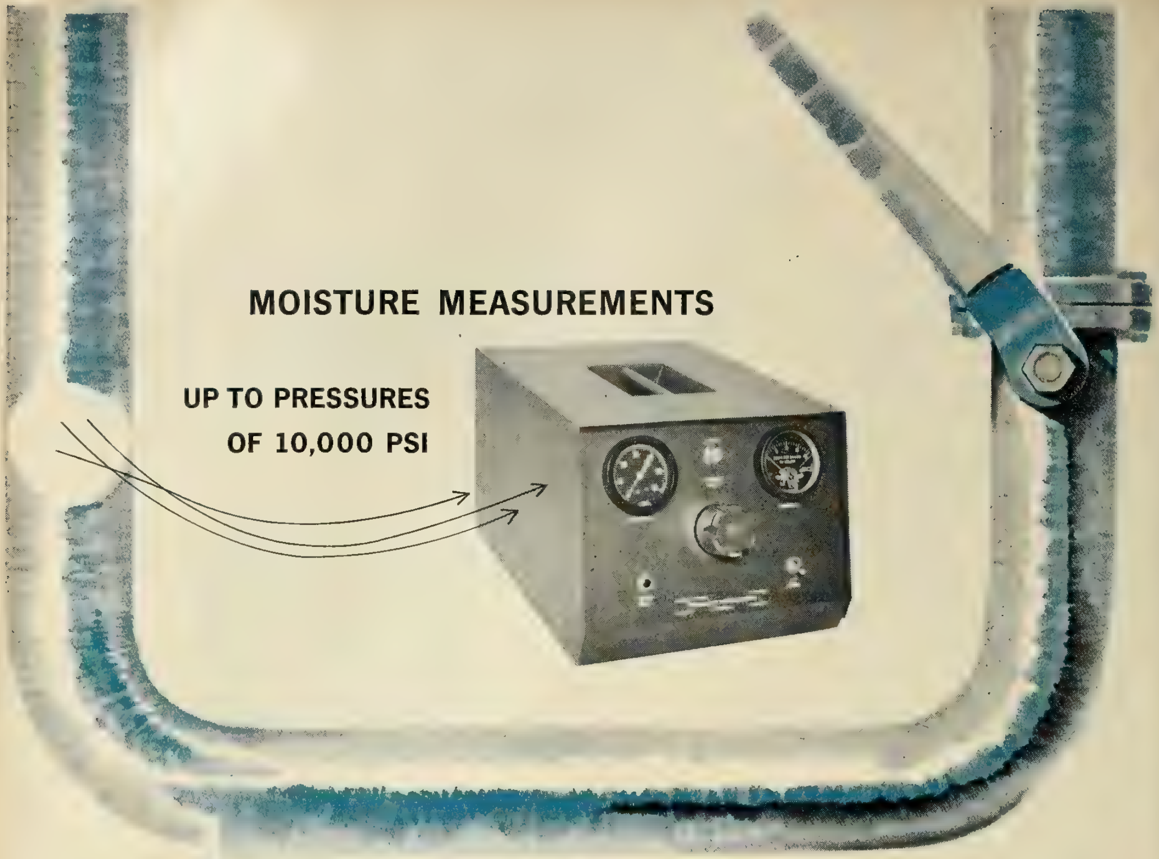

Here's the newest addition to CEC's line of moisture monitors . . . the high-pressure 26-350 Series. Available in several models, they measure trace quantities of water in gases and gaseous mixtures at pressures up to 10,000 psi. These "absolute" instruments require no calibration . . . deliver precise data with full-scale response in 90 seconds. They operate over a moisture range of 1 ppm to 1,000 ppm, and provide continuous readings on a rugged meter calibrated in ppm water by volume. When moisture content exceeds desired limits, adjustable alarm contacts actuate audio/visual signals . . . during either batch or continuous sampling operations.

A battery-pack accessory plugs inside the case for portable use of the 26-350 Moisture Monitors in remote areas where line power is not available. **Other outstanding members of the CEC Moisture Monitor family** include the industry-proved 26-301 and 26-302 Laboratory and Extended-Range Moisture Monitors, designed for standard applications and providing operating ranges of 1 - 1,000 ppm and 1 - 20,000 ppm, respectively. And now measurements of water content in liquids can be accomplished with CEC's Liquid Moisture Monitor—newly developed for laboratory and process applications. Call your nearest CEC sales and service office for details, or write for Bulletin CEC 1851-X2.

Analytical & Control Instrument Division CEC

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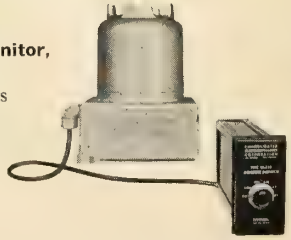
CEC's 26-310 Process Moisture Monitor, designed for continuous in-plant operation, assures precise monitoring of process streams – even in Class I, Group D, Division 1 hazardous locations.



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in by direct means.

While subjected to temperature changes, the chamber occupant must concentrate on a tracking problem by chasing a random dot on an oscilloscope and place it in the scope center by manipulating ultra-sensitive controls in the dummy cockpit.

The 45-minute-long tests deliver data on environmental temperatures, body temperatures, blood pressure, respiration, and electrocardiographic information in addition to psychological reactions. The subject is closely monitored by closed circuit television.

AEC Names Group To Study Human Factors

WASHINGTON—The Atomic Energy Commission and the Air Force have named a six-man team to define human factors problems of the aircraft nuclear propulsion program (ANP). Designated the Life Sciences Working Group, it will meet semi-annually at Air Force, AEC, or contractor facilities to examine health and safety characteristics of specific propulsion systems.

The group is composed of Maj. Charles M. Barnes, USAF, of the ANP Office, Chairman; Dr. Leo K. Bustad, General Electric Co.; Dr. Titus C. Evans, State University of Iowa Medical School; Col. Gerrit L. Hekhuis, School of Aviation Medicine, USAF; Dr. Donald M. Ross, Biology and Medicine Division, AEC; and Dr. Arthur C. Upton, Oak Ridge National Laboratory.

Aerojet Constructing Boron Pilot Plant

SACRAMENTO—Construction of a large pilot plant on Aerojet-General Corporation's 20,000-acre facility near here is underway following assignment of a $2,000,000 USAF prime contract to Stauffer-Aerojet Chemical Co. for production of high-energy boron fuels.

A new process for production of the new fuels—which are expected to increase the range of missiles, rockets, ramjets and jet aircraft—was developed by the chemical firm formed a year ago as a joint venture of the Stauffer Chemical Company of New York and Aerojet-General, a subsidiary of General Tire and Rubber Co.

J. B. Cowen, 40, Aerojet employee since 1947, has been appointed to the newly-created position of manager of administration for the Solid Rocket Plant. He has been manager of manufacturing at the same plant. His job will be to supervise contracts, materiel, customer relations and technical services.

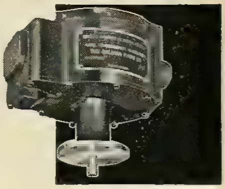
SUBMINIATURE 13-DIGIT ENCODER *for airborne or other limited space applications. Detailed specifications in Bulletin 0858.* **SIZE:** *2⁹⁄₁₆" dia. x 3¾" long; ¼" dia. shaft, ⅛" long.* **WEIGHT:** *1¼ lbs.* **OVERALL ACCURACY:** *± 1¼ quanta in 8192.* **READOUT RATE:** *Model A, nominally 10KC (50 microsecond pulse), max. of 100KC (5 microsecond pulse). Model B, max. of 200KC for element, 10KC for sequence.* **MAXIMUM ANGULAR SPEED OF ROTATION AT FULL ACCURACY:** *2 rpm (6 rpm at 12-digit accuracy). 10 rpm with temperature control.*

Model A2.6SS13
(Parallel readout)
Model B2.6SS13
(Sequential readout)

4" DIA. 13-DIGIT ENCODER *for general purpose applications. Detailed specifications in Bulletin 0958.* **SIZE:** *4" OD with protrusions on one side x 7" long; ¼" dia. shaft, 0.67" long.* **WEIGHT:** *9¼ lbs.* **OVERALL ACCURACY:** *± 1 quanta in 8192.* **READOUT RATE:** *100 cps, max.* **MAXIMUM ANGULAR SPEED OF ROTATION AT FULL ACCURACY:** *720 rpm; maximum rotation rate, 600 rpm.*

Model A4DP13

6" DIA. 13-DIGIT ENCODER *for general purpose applications. Specifications in Bulletin 1058.* **SIZE:** *6³⁄₁₆" dia. with protrusions x 7¾" long; ½" dia. shaft, 1" long.* **WEIGHT:** *14 lbs.* **OVERALL ACCURACY:** *± 1 quanta in 8192.* **READOUT RATE:** *100 cps, max.* **MAXIMUM ANGULAR SPEED OF ROTATION AT FULL ACCURACY:** *720 rpm (10 microsecond pulse).*



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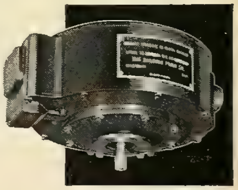
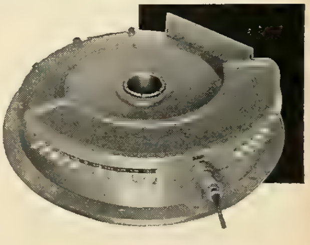
9" DIA. 16-DIGIT ENCODER *precision unit for radar applications. Detailed specifications in Bulletin 1158.* **SIZE:** *9¹⁄₁₆" dia. with protrusions x 4⅜" high; ½" dia. shaft, 1¼" long.* **WEIGHT:** *17½ lbs.* **OVERALL ACCURACY:** *± 1 quanta in 65,536.* **READOUT RATE:** *100 cps, max.* **MAXIMUM ANGULAR SPEED OF ROTATION AT FULL ACCURACY:** *90 rpm (10 microsecond pulse).*



Model A9SP16

HIGH PRECISION 18-DIGIT ENCODER *for radar or theodolite applications. Detailed specifications in Bulletin 1258.* **SIZE:** *21" max. dia. x 8¹⁄₁₆" high.* **WEIGHT:** *169 lbs.* **OVERALL ACCURACY:** *± 1 quanta in 262,144.* **READOUT RATE:** *100 cps, max.* **MAXIMUM ANGULAR SPEED OF ROTATION AT FULL ACCURACY:** *25 rpm (10 microsecond pulse).*

*Encoders with decimal, trigonometric functions and other nonlinear codes are also available. All disks are made on a special divided circle machine designed and built by Baldwin. *Write for descriptive bulletins.*



Model A21SP18

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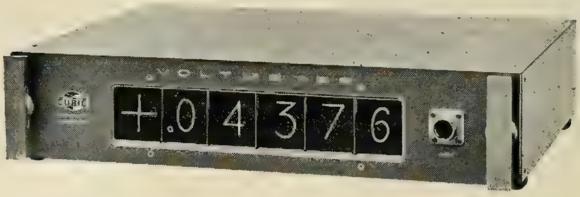
SPECIFICATIONS

Available with 4 digit (Model V-41) or 5 digit (Model V-51) display, the Digital Voltmeter is powered by Control Unit Model C-1, which includes a power supply, precision reference and differential amplifier, and which, separately housed, supplies power to as many units as are required in a Digital System. The Cubic Voltmeter provides an accuracy of .01% plus or minus 1 digit, between ±.0001V and ±999.9V (Model V-41) and ±0.0001V and ±999.99V (Model V-51). Low level voltages ±10 microvolts may be measured by the addition of the Preamplifier unit, Model PA-1.



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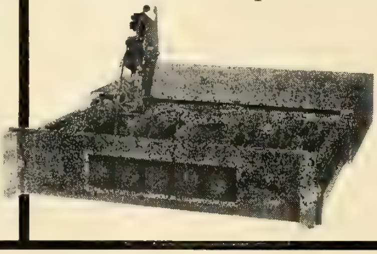
Space Age know-how that goes into Cubic Corporation's missile tracking systems is also an important engineering and production component of Cubic DC Voltage instrumentation. The 4-digit and 5-digit Voltmeters, powered by the Cubic Control Unit, offer such quality features as unit plug-in construction, a precise two-part filter that eliminates the effect of AC ripple on DC readings, shock-mounted stepping switches with "controlled drive," in which the switch turns off the drive circuit part way through its cycle, ending overdrive and eliminating impact wear. Clear visual display is provided by an ultra-brilliant, edge-lighted read-out containing in-line numerals one inch high. Transistorization ends warm-up time, lengthens instrument life. Cubic's attention to fine detail increases the precision, reliability and functional capability of each instrument and at the same time provides such outstanding features of standardization as printed circuit boards that are interchangeable and stepping switches that swing up and out for ease of routine maintenance. Cubic quality is your guarantee of truly fine instrumentation.



Unit construction of the Cubic Voltmeter and other Digital instruments provides maximum flexibility in creating "systems that design themselves." Inter-*case* wiring and standard-size plug-in units make every Cubic System a customized system using standard units. "Building Block" units which can be added easily to increase systems capabilities are the DC Preamplifier, AC-DC Converter, Digital Ohmmeter, Ratiometer, Master and Auxiliary Scanners and Printer Control Units. Write today for further information.

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Interplanetary Guidance for Man in Space

Existing components will be accurate enough for unmanned probes with possible radio control for cutoff and staging. But next generation of manned vehicles will impose a different set of requirements headed by reliability.

by Lawrence S. Brown

Manager, Missile Development Division, Ford Instrument Company—Division of Sperry Rand. Chairman of the Instrumentation Committee, American Rocket Society

LONG ISLAND CITY, N.Y.—The guidance and instrumentation hardware for interplanetary travel is in being. Present techniques and existing components have been used successfully to guide space vehicles, albeit on a limited scale. The rapid advance of the past 15 or so years has been truly remarkable.

Although the next 15 years inevitably will see the refinement of present mechanisms, breakthroughs into exotic realms during this period are unlikely. Fundamental principles of physics relating to the guidance of an object through space will be exploited with increasing success. But until new, perhaps relativistic, ideas are evolved, we shall have to be content with increasingly sophisticated applications of Newton's laws. Here, the ultimate limitation imposed by attainable machining tolerances is rapidly being approached.

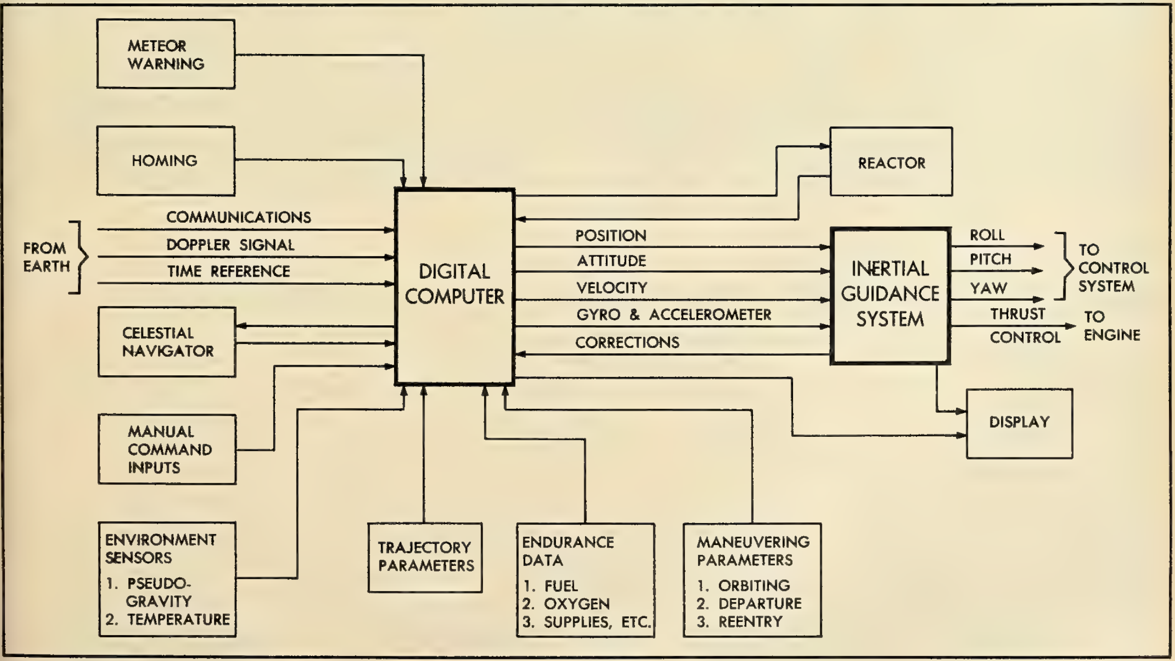
- **Present possibilities**—Nevertheless, existing components will be accurate enough for the first generation of space vehicles. These vehicles, already aloft or in advanced stages of development, are satellites and lunar and planetary probes—all unmanned. Present guidance systems can put a payload into orbit around the earth or a probe in the vicinity of the Moon, Mars or Venus. The international competition for space will prompt early launchings of increasingly ambitious vehicles of these types.

For some time to come, their guidance systems will be essentially identical to those of the ballistic missiles from which they are evolving—inertial components active until first- or second-stage cutoff, with possible radio control for cutoff and staging.

The accuracies attainable with these schemes will be acceptable as long as the payloads consist of instruments or animals. Ultimately, however, man will be satisfied only with transporting into the heavens that most versatile and discriminating of data-processing and decision-making instruments—himself. If progress continues at its present rate, vehicles for this purpose may well be on the launch pad by 1965.

- **New specifications**—Instrumentation for manned space navigation poses an entirely different set of requirements than does the "shot from guns" approach of current ballistic missile systems. The governing consideration is *reliability*. There is little purpose in sending a man into space without assurance that his vehicle will safely transport him to his destination and back to earth.

Here then is *the* challenge to our science and industry: to design guidance systems of *inherent* reliability and ruggedness, for these characteristics cannot be tested into a component. A round trip to the nearest planets may take two years or more. The physical environments to be encountered are still largely unknown. There will be little or no opportunity for maintenance or repair. The possibility of outright failure of a component must be reduced to the absolute minimum, and serious deterioration of performance is inadmissable. The specifications for a manned space vehicle will be the most



PROPOSED OVERALL block diagram for guidance system of the future using a digital computer as the central element.

rigid to be presented to industry.

The "breakthrough" necessary for space travel is a reversal of the current trend towards complexity of design. Leaning towers of electromechanical and electronic components and the philosophy of "Well, to fix that suppose we add this" will not provide the answer.

- **Digital emphasis**—Digital techniques will be widely employed, not only in computation but in stabilization, gyro and accelerometer control, program storage, power supply regulation, etc. This is all to the good for, in addition to their inherent accuracy, digital circuits can take full advantage of micro-miniaturization, printed circuitry, semi-conductors and modular construction. Digital guidance and control instruments give every promise of being small, light, rugged and reliable. The missile industry is giving them increasing attention.

- **Improved mechanics**—Mechanical components (and their attendant problems) cannot be dispensed with entirely. Stable platforms, gyros and accelerometers in somewhat their present configurations will be with us for a long time. Here, reliability and size requirements tend to conflict. Gyro accuracy, for example, being proportional to rotor angular momentum, demands large rotors and high speeds. The first is undesirable from the standpoint of size; the second from the standpoint of reliability. A possible solution may lie in the application of gas hydrodynamic bearings to gyro rotors.

Such bearings, offering negligible friction and wear, could permit rotor speeds on the order of 250,000 rpm. Presently attainable minimum gyro drifts (as low as 1/50th of a degree/hour) could thus be reduced by a factor of about ten. Reduced gyro and accelerometer drift would not only improve in-flight accuracy, but also make possible more precise initial alignment of the stabilization system.

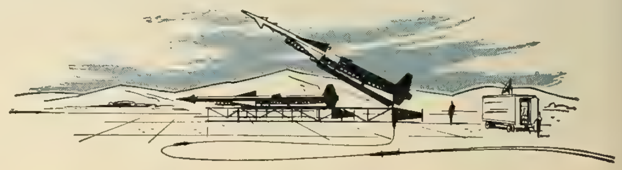
- **New accelerometers**—Accelerometers probably will undergo more design changes than other guidance components. Present accelerometer sensitivities extending down to 10^{-4g} will need improvement, perhaps to as low as 10^{-12g}. Gyroscopic accelerometers may give way to vibrating string types, rotating pendulums, or airfloated, magnetically-restrained pendulums. These are but a few of the advanced designs being studied or tested. Since the upper measuring limit of such ultra-sensitive accelerometers will probably not be much greater than 10^{-4g}, we may also require an auxiliary set of conventional accelerometers capable of measurements to 20g.

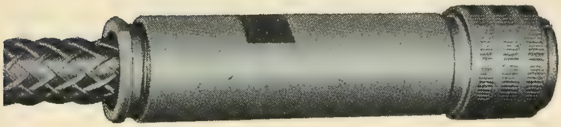
Present accelerometer accuracies of one part in 10^5 can probably be retained in the smaller measuring ranges and should prove adequate. Reliability of the new types is, however, still an unknown factor, and it may be necessary to develop more sensitive varieties of the proven gyroscopic pendulous accelerometer.

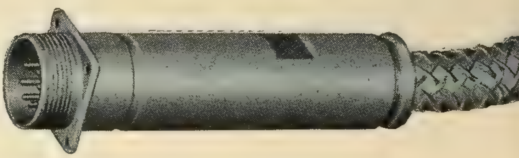
Implicit in all component design problems is the guidance and control system in which the components are to be employed. Systems jury-rigged from a random assortment of components, no matter how sophisticated or ingenious, are destined to fail. As always, reliability, accuracy and minimum size will govern selection. Given these requirements, what type of guidance systems can be envisioned for space vehicles of the near future?

It appears quite certain that system design will follow an extension and combination of present-day concepts. We will choose from among inertial, star-tracking, radio command, and homing systems. Each has certain desirable attributes and may be used singly or in combination with other systems depending upon the particular mission involved.

- **Suggested script**—The program for further space exploration probably







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These are a few of the reasons it will pay you to specify the Bendix QWL electrical connector for the job that requires exceptional performance over long periods of time. *TRADEMARK

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This is one of a series of informative messages to acquaint engineers and scientists with the projects of RCA Moorestown.

RCA MOORESTOWN AND ATLAS

Responsibility for the development, design and production of an advanced launch control system for the Atlas missile is one of the charters of RCA Moorestown. The system is designed to perform two primary functions: To determine the operational readiness of the missile and to control the actual launching of the ICBM into space.

The Atlas launch control system complex requires over 200 cabinets of relay logic and newly developed transistorized digital and analog computer circuitry. Of critical significance in the development of the complex are the problems of reliability and accuracy, necessitating the use of advanced transistorized techniques. The challenge of the project is increased by the need for obtaining and integrating information from many associate contractors and by the problems of concurrent research, development and production. The breadth and complexity of the Atlas launch control system are creating stimulating assignments in systems, projects and development engineering.

Engineers, scientists and managers interested in contributing to this program—or to other challenging weapon system projects—are invited to address inquiries to Mr. W. J. Henry, Box V-13B.

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RADIO CORPORATION of AMERICA
MISSILE AND SURFACE RADAR DEPARTMENT
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should read like this:

ACT I

Scene 1. Unmanned probe to orbit or impact the moon.

Scene 2. Unmanned probe to the vicinity of Mars and/or Venus.

Scene 3. Manned, recoverable earth satellite.

(Intermission)

ACT II

Scene 1. Manned vehicle to orbit moon and return.

Scene 2. Manned, permanent earth satellite.

Scene 3. Manned landing on lunar surface and establishment of permanent station.

(Intermission)

ACT III

Scene 1. Manned vehicle to orbit Mars or Venus and return.

Scene 2. Manned landing on Mars or Venus, exploration, and return.

Unmanned probes of the moon and neighboring planets will continue to use inertial guidance systems with varying degrees of assistance by radio-controlled cutoff and staging. These systems offer a reasonable probability of success, though their accuracy is not likely to ensure impact on the moon or establishment of planetary orbits. Terminal guidance homing on the albedo of the moon or planets may be attempted. The probes to Mars and Venus tentatively scheduled for this year may well be equipped with a photoelectric homing device to supplement their midcourse guidance.

Whether or not these probes reach their advertised targets, their escape from the earth's gravitational field will render the experiments successful, for a great deal will be learned about the performance of systems and components in outer space. Considerable effort is being devoted to improving electrical power sources and reducing power requirements to prolong the operation of components in such an environment.

- **Man in Space**—By 1960, the "Man in Space" program probably will be well underway. Its guidance and control problems will exceed those of the previous satellite programs. It will take some doing to provide the necessary degree of reliability and successful re-entry, but again, present inertial guidance systems coupled with other techniques appear adequate for at least the initial experiment.

It is unlikely that the human passenger will play the primary role in guiding this first manned vehicle. Man's reaction to the new environment is unpredictable, and he may not be physically or psychologically able to interpret data accurately or make and carry out decisions. Radar commands from ground computers probably will sup-

MEETS CLASS A SNT ULTRASONIC SPECIFICATIONS

Alcoa alloy 7079, used as a standard forging alloy for the last four years, is now available in high-strength plates for a wide variety of structural applications in the aircraft and missile industry. Already successfully used in the Convair 880 commercial jet airliner, the B-58 supersonic bomber and the Atlas Missile, production of this superior aluminum plate was made possible through Alcoa's new fabricating technique.

Available in thicknesses from 3 in. to 6 in., alloy 7079-T651 guarantees minimum mechanical properties in longitudinal, long and short transverse directions.

In plates 3 in. or thicker, alloy 7079 exhibits greater uniformity of mechanical properties, and in addition possesses greater ductility than any other high-strength alloy. Alloy 7079-T651 plate is stretcher stress relieved 1½ to 3 per cent and may be machined to yield large parts with minimum distortion.

Identified by the approved Alcoa inspection stamp, alloy 7079 plate is ultrasonically inspected to Class A acceptance limits of the SNT Airframe Committee Report No. 1.

Call your Alcoa sales engineer for additional facts about alloy 7079-T651. He'll work with you in exploring and adapting its many advantages for better and lower cost products. Aluminum Company of America, 2029-B Alcoa Building, Pittsburgh 19, Pa.

GUARANTEED MINIMUM MECHANICAL PROPERTIES—7079-T651 PLATE

Thickness Inches	Direction	Tensile Strength ksi	Yield Strength ksi	Elongation Per Cent in 2 in. or 4D
3.001-4.000	Longitudinal	70	60	6
	Long transverse	70	60	5
	Short transverse	64	55	2
4.001-4.500	Longitudinal	68	58	6
	Long transverse	68	58	5
	Short transverse	62	54	2
4.501-5.000	Longitudinal	68	58	5
	Long transverse	68	58	5
	Short transverse	61	53	2
5.001-5.500	Longitudinal	67	58	4
	Long transverse	67	58	4
	Short transverse	60	53	2
5.501-6.000	Longitudinal	67	58	4
	Long transverse	67	58	4
	Short transverse	59	52	2

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plement on-vehicle guidance.

If the "Man in Space" program succeeds in proving that man can survive and function in space, it certainly will be followed by a manned lunar vehicle. In that case, the capabilities of the human passenger would be utilized to the fullest. Admitting man as an active part of a missile guidance and control system will entail significant changes in existing system concepts.

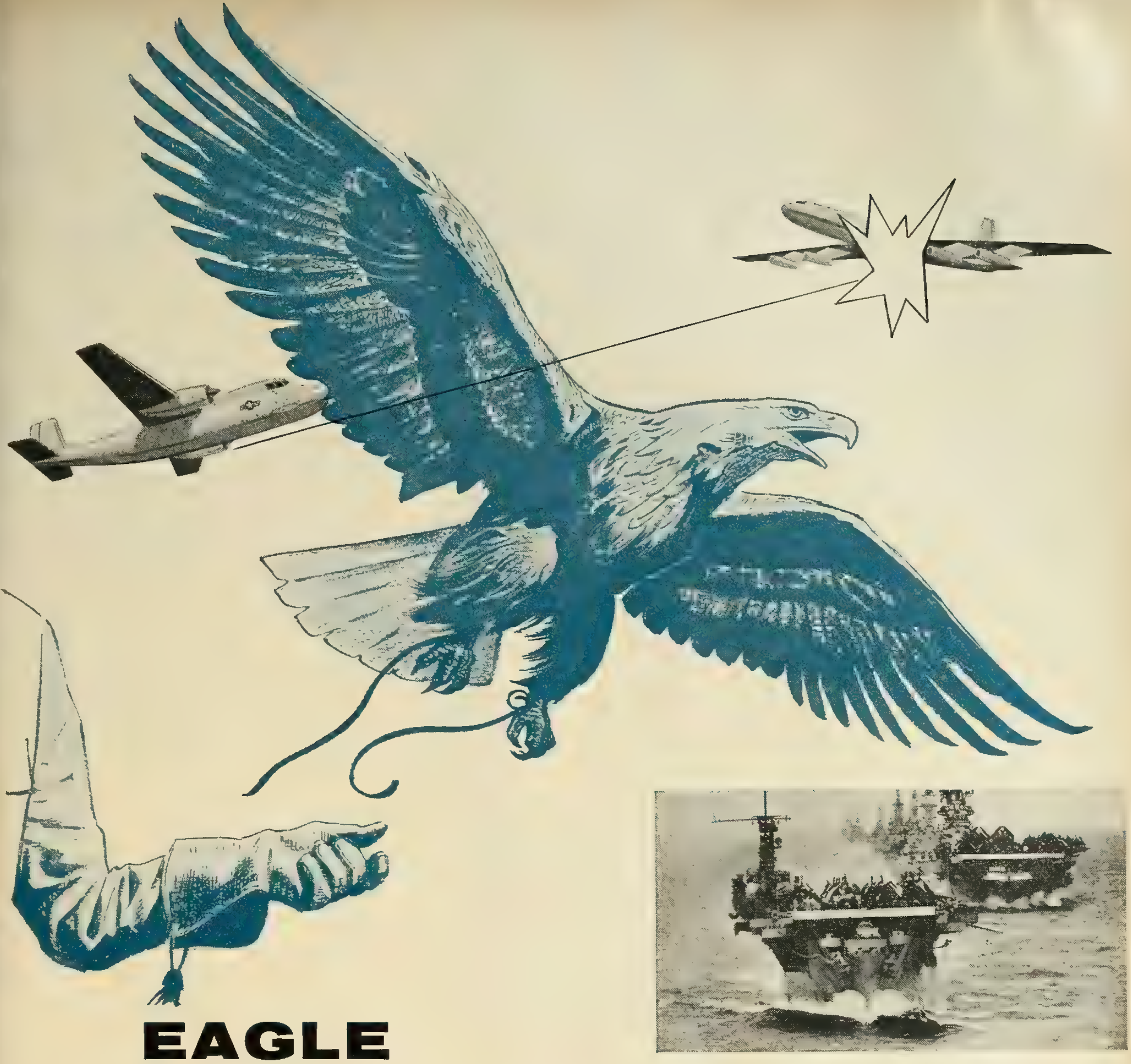
- **Pilot control**—A manned vehicle probably will be "flown" in much the same sense that an airplane is. The ballistic concept will give way to a navigational guidance system in which corrections will be made throughout flight at the discretion of the pilot and/or guidance system. Although all functions will be made fully automatic to anticipate human failure, the pilot will at all times be able to override the system and enforce his own decisions.

This will require some form of present position and velocity display, together with a reference display indicating the desired values for these quantities, the errors, and whether the guidance system is responding to correct the errors. Necessary reference information and guidance commands may be transmitted from the ground.

On the other hand, the system will have to guard against illogical or dangerous commands by the pilot. Fuel and supply reserves, vehicle stresses, engine temperatures, and other considerations not immediately apparent to the pilot may require that an obviously indicated correction be delayed or modified. Certainly, human engineering principles will have to be amalgamated with existing system concepts if we are to integrate man and machine.

- **Something like SAGE**—Maneuvers such as establishing an orbit around the moon, departure from orbit, and re-entry must be precisely timed and executed. This concept embodying the necessary relation between man, machine, and external guidance is most nearly approached by our newest, SAGE-controlled manned interceptors. There, the pilot, though assisted and directed by radar commands, can exercise his own judgment and make the final decisions. The guidance and control system for the manned lunar vehicle may well combine such principles with conventional inertial components.

- **Manned station**—The next step would be construction of a manned space station, generally conceded to be a necessary prelude to launching an interplanetary vehicle of appreciable size. Only by piecemeal assembly of material and fuel can a large-scale interplanetary vehicle become feasible. (It has been calculated that, without a space station, a large Mars vehicle de-



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parting from earth would consume over 100 tons of fuel during the first second of takeoff.)

A mass in orbit, however, is already travelling at nearly escape velocity. A vehicle assembled at the space station could thus depart from the orbit under the small thrust available from the ionic engines envisioned for interplanetary flight. Although some 68 tons of fuel would be necessary to place each ton of payload into orbit, the necessary bulk could be delivered incrementally by vehicles of reasonable size.

The space station would also be valuable as a proving ground for guidance and control components. Gyros and accelerometers designed to function outside the influence of gravity could be evaluated in the environment of space. Uncertainties in the measurement of earth's gravity would degrade test data of an accelerometer designed to measure down to 10^{-12}g. A gravity-free space station would provide the ideal laboratory for test and calibration of inertial components.

Guidance systems for the rockets assembling the space station and for the supply vehicles will be of the manned inertial style similar to (but less complex than) those proposed for the lunar vehicle. Terminal guidance homing on a radar beacon in the space station will be a necessity.

The sheer number of flights needed to assemble and provision a space station in preparation for a Mars vehicle would serve to evaluate and improve components and vehicles.

• **To the planets**—Once the space station becomes a going concern, the design of a manned interplanetary vehicle will proceed apace. It must be assumed that nuclear power plants will be available—not only for propulsion, but for auxiliary power as well. Conventional batteries cannot provide instrument power for a lengthy voyage, and there will be practical limitations on redesigning instruments for minimum power.

In principle, chemical fuels would suffice for an interplanetary vehicle, but the probability of success of a chemical rocket is rather marginal. The most likely application of nuclear power to rockets appears to lie in an ion engine. Heat from an atomic reactor would be converted into electric power to generate and accelerate propelling ions. Adequate sub-system power would then also be available.

The guidance and control system would reflect this choice of power plant. The extremely low accelerations developed by an ion engine (as low as 10^{-4}g) means that propulsion would be active during the entire flight. For approximately half the journey, the vehicle would accelerate; thereafter, the thrust would be reversed to decelerate it for orbiting or landing.

The orbit could be established by landing on one of the tiny satellites of Mars. These bodies, having negligible gravity, would permit limited exploration and the establishment of structures and facilities. In effect, a service station could be left behind for subsequent vehicles.

The use of continuous propulsion will permit the monitoring of errors to achieve small but continuous corrections. This calls for extremely sensitive inertial components. A 10^{-12}g acceleration error, which would be trivial in a ballistic missile of 5000-mile range and 30 minute flying time, becomes significant over a distance of 40,000,000 miles and a time of 400 days. It is doubtful that present inertial systems will, by themselves, be capable of the required accuracies over such prolonged intervals. Celestial observations will be necessary for continuous monitoring and correction of the inertial system.

• **Guiding stars**—The fixed stars, such as Vega, Regulus and Aldebaran, would provide the reference frame for vehicle attitude. Nearer celestial bodies,

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in which parallax can be observed (Earth, Mars, the Sun, and Jupiter, for example), would be used as positional references.

Celestial observations will require extremely accurate time references (perhaps ammonia MASERS) which may not be readily transportable. Some equipment could, of course, remain on earth and necessary information could be radioed to the vehicle. A radio data link would also give doppler velocity information as a further check on the inertial guidance system. The inertial system may thus evolve as a "middle man" between the celestial navigation and data link equipment on the one hand, and the vehicle on the other.

The vehicle's instantaneous reference will be with respect to the inertial system which will, in turn, be continuously adjusted by the star trackers and doppler.

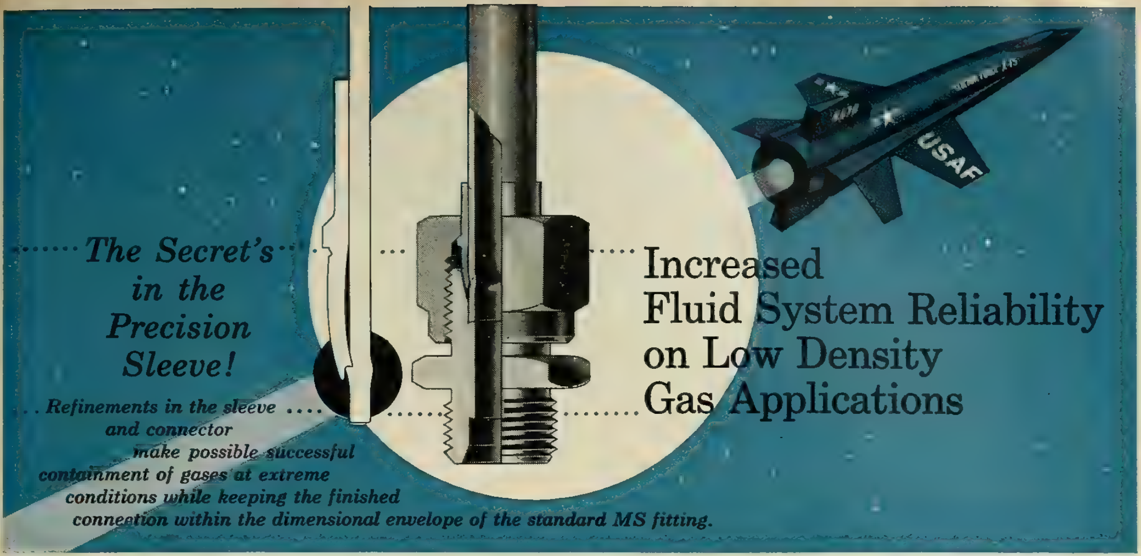
Present star observation systems are accurate to approximately 4 seconds of arc and doppler velocity can be measured to within ½ foot per second. Within these limits, the error at 40,000,000 miles would be less than 10,000 miles (1 part in 40,000) and could readily be corrected by a homing device or by visual observation.

• **Help from computer**—Other aspects of the guidance system, primarily involving action by the pilot, include: center of gravity control; meteor collision warning and avoidance; communications; homing; and data display. One can envision a rather elaborate digital computer to oversee these matters and to advise and instruct the pilot. The computer would also serve to control and to interpret the celestial observations, apply corrective signals to the inertial system, and continuously plot the most suitable trajectory. Logic components now in the laboratory will, in time, reduce such a computer to a package of reasonable size and complexity.

Communications between the vehicle and earth for the doppler system and other purposes appear entirely feasible. Recent advances in the fields of radio astronomy and satellite telemetry have given us the techniques and components which will permit effective transmission and reception at extremely long distances.

Fifteen years ago a program such as outlined here would have been dismissed as visionary. Today it can be considered a realistic prediction. Fifteen years hence it will be an accomplished fact.

For we shall truly see these refinements as guidance is exploited with increasing success.



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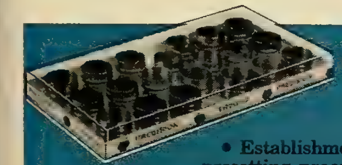
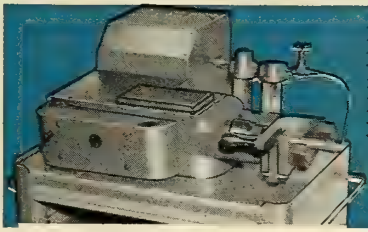


- Special protective packaging of precision sleeves in sealed containers.
- Establishment of uniform presetting procedures, for the material combinations required, which result in a sleeve that does not rotate on the tubing.

This is another example of Weatherhead's policy of continuing research to develop products in advance of industry's needs — another reason why Weatherhead pneumatic and hydraulic components are currently in use on such vehicles as Atlas, Bomarc, Nike-Ajax, Thor, Jupiter, Bullpup, Polaris, Redstone and the North American X-15 manned aircraft. Look to Weatherhead for the "precision answer" to your fluid system requirements!



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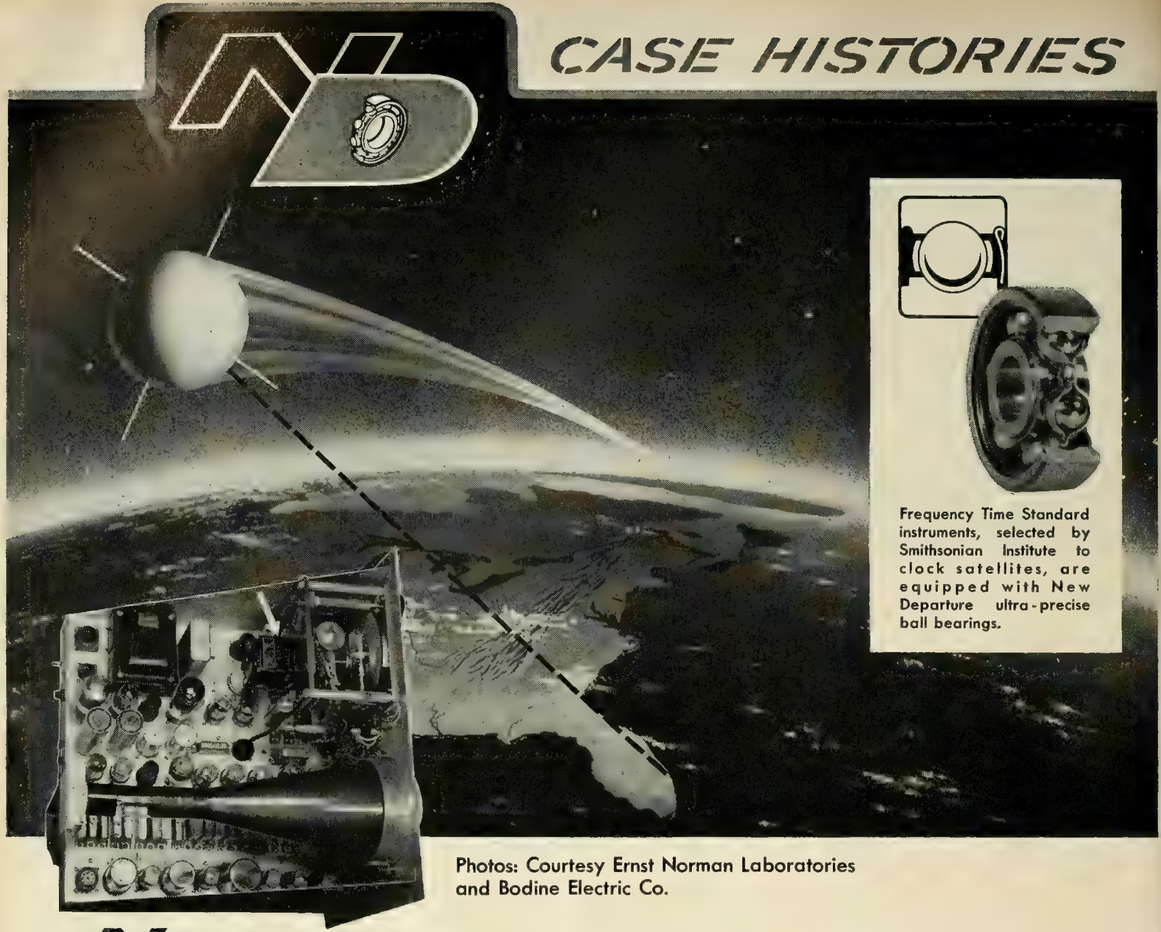

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USAF Reports Issued on Capacitors, Transistors

WASHINGTON—The government has released USAF reports describing a loaded resinous system as a high dielectric constant material for solid wound capacitors and reviewing recent research on development of a silicon power transistor.

The first report, "Solidified Wound Capacitors," is numbered PB 151203 and is available from the Office of Technical Services, U.S. Department of Commerce, Washington 25, D.C., for $2.50. It discusses a loaded resinous system, epoxy-titanium dioxide, successfully applied as a high dielectric constant for solid wound capacitors.

The capacitors showed long-time performance at high temperatures under operational voltage, with the high dielectric constant supplying a substantial volume reduction for a given capacitance.

The epoxy-titanium dioxide material applied in films of one mil or less on aluminum foil yielded dielectric constants of 15 to 19. Flat plate capacitors of coated aluminum foil tested at 150C and applied voltages of 105 and 210 volts DC operated successfully over 1000 hours. They maintained capacitance, dissipation factor and insulation resistance. Highest microfarads produced at 150C was 54.

Wound capacitors of coated aluminum foil with the dielectric material also operated 1000 hours at 210 volts DC. The report includes descriptions of the dielectric, its application to aluminum foil and porous paper, measurement facilities and sample capacitors.

The other report, titled "Semiconductors Devices Research Program," is numbered PB 151201 and is available from the same address for $3. It says that developmental research showed that silicon power transistors can be fabricated by diffusing impurities in from the surface to form the base and emitter regions. Gallium and phosphorus were the impurities most thoroughly studied. The simultaneous diffusion process was used for transistor fabrication in pilot experiments and the effects of external variables upon this process were determined.

Emitter, base and collector contacts were made using titanium or tungsten support plates. The transistors were mounted in a hermetically sealed, welded package of low thermal resistance. The fabrication process included diffusion, lead attachment, etching and packaging.

Characteristics of preliminary laboratory units are given.

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PANORAMIC TELEMETERING SUBCARRIER DEVIATION AND THREE POINT CALIBRATOR (Model TMC-1) is a dual-purpose instrument. Its normal mode of operation is to furnish sequentially upper limit, center, and lower limit frequencies, channel by channel, for all RDB channels as outputs for discriminator calibration. Secondly, it operates with the Panoramic Telemetering Indicator (described above) to establish maximum deviation limits and center frequency of subcarrier oscillators.

PANORAMIC SEVEN POINT TELEMETERING FREQUENCY CALIBRATOR (Model TMC-307a) sequentially furnishes seven equally spaced frequencies with .02% accuracy for each IRIG channel to calibrate subcarrier discriminators.

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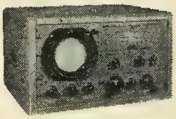
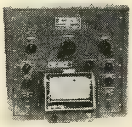
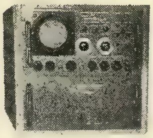
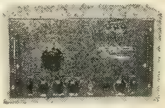
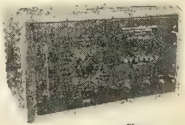
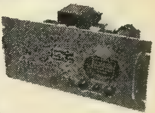

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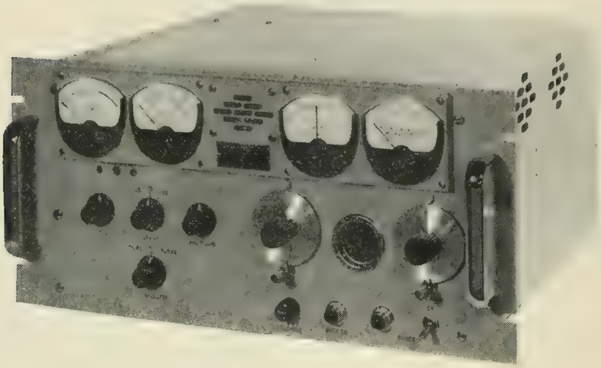

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Noise figure	less than 8 db
Video output	Sensitivity: 0.16v peak-to-peak per kc of deviation. Frequency response within 3db. AC coupled, 10 cps to 100 kc per second. Adjustable output control on front panel.
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Signal Strength Recorder Output	High impedance, 0-15v
Spectrum Display Output	30 mc
Input Impedance	50 ohms nominal
IF Rejection	Greater than 60 db
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contract awards

ARMY

$1,887,027—**Nortronics Division, Northrop Corp.,** for check out equipment.

$1,007,435—**Douglas Aircraft Co., Inc.,** for launching area items and repair parts.

$425,537—**Western Electric Co.,** for *Nike* spare parts and components (11 contracts).

$132,863—**Forest Builders, Inc.,** Pittsburgh, Pa., for construction of warhead buildings and related facilities at *Nike* launcher sites in Pittsburgh area.

$99,100—**Massachusetts Institute of Technology,** for studies of the spectra of vertical fluxes of momentum, heat and moisture in the atmosphere boundary layer.

$60,999—**H. I. Lewis Construction Co., Inc.,** Middletown, Pa., for construction of buildings and related facilities at *Nike* launcher sites in Cleveland, Ohio, area.

$55,555—**Dick Corp.,** Large, Pa., for *Hercules* conversion of underground missile storage structures at launching sites in Pittsburgh area.

$48,360—**Missile Air Division, United States Chemical Milling Co.,** Manhattan Beach, Calif., for bulkheads.

$32,364—**Raytheon Manufacturing Co.,** for field maintenance on *Hawk.*

$31,433—**California Institute of Technology,** for R&D.

AIR FORCE

$1,800,000—**Vitro Laboratories Division, Vitro Corporation of America,** for operation and maintenance of land and water ranges at the Air Proving Ground Center, Eglin AFB, Fla.

$346,324—**Hughes Aircraft Co.,** for overhaul, repair and modification of *Falcon* system items.

$200,000—**Avion Division, ACF Industries, Inc.,** for radar beacons for *Titan* nose cones. (A series of sub-contracts from Avco Mfg. Co.)

$162,028—**Eclipse-Pioneer Division, Bendix Aviation Corp.,** for angular accuracy testers, test stands, and maintenance and engineering data.

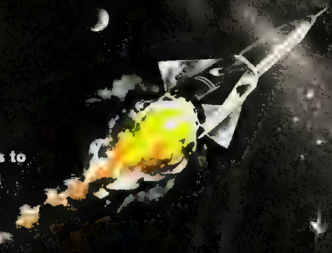
$59,997—**Douglas Aircraft Co., Inc.,** for modification kits for loading latch assembly on *Genie.*

$49,991—**Chu Associates,** Littleton, Mass., for study of multiple beam interval scanner for AICBM radar antenna.

ELECTRO SNAP

Creators of over 6,000 Precision Switches and Controls

presents . . . A new panel concept that promises to
revolutionize monitoring or control
of Missiles and Rockets

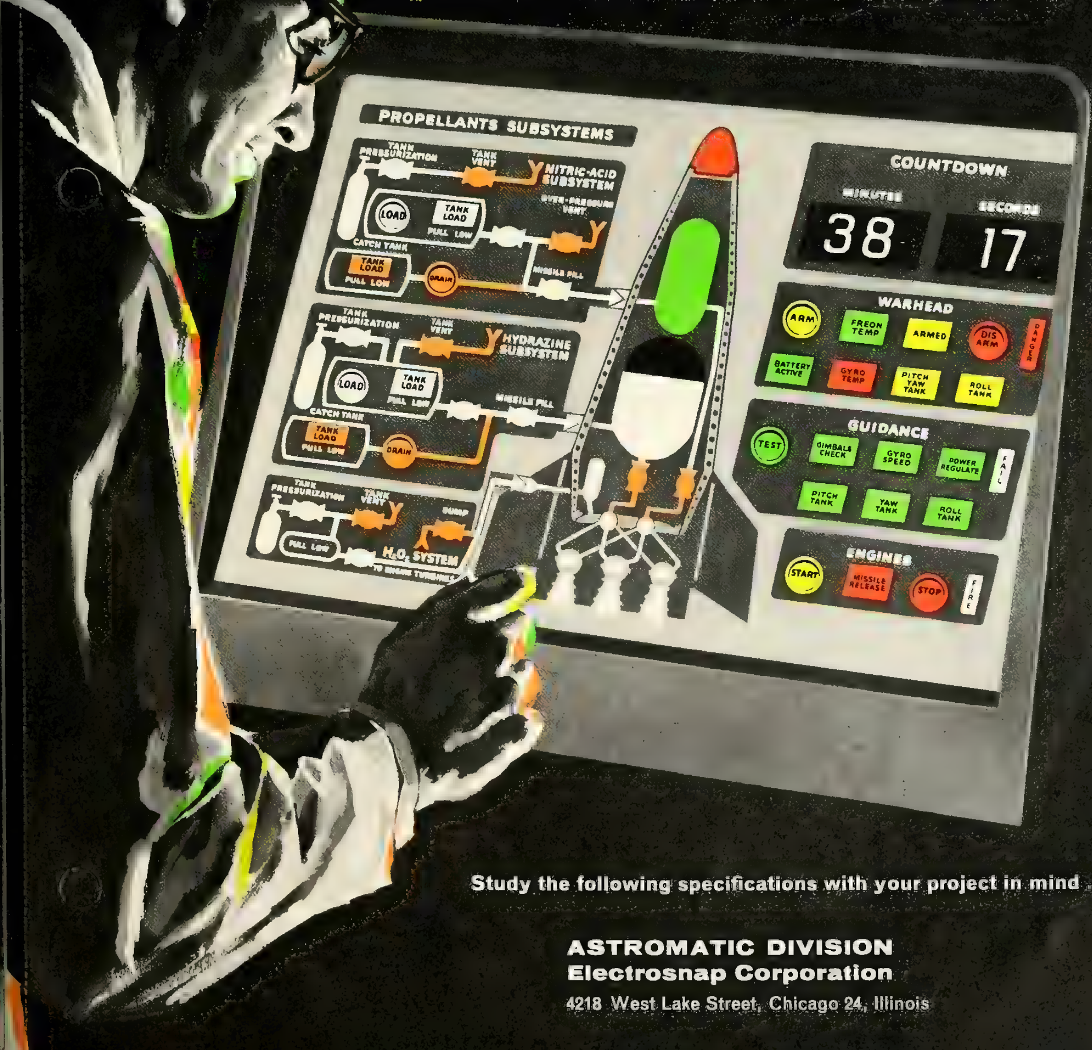


the astromatic panel concept

"THE MOST EFFICIENT LINK BETWEEN MIND AND MACHINES"

Consider These Obvious Advantages in Your Designing

- ★ OFFERS INSTANT VISUAL CONTROL WITH EXTREME ACCURACY
- ★ REDUCES HUMAN ERROR TO AN IMPROBABILITY
- ★ PROVIDES SIMPLIFICATION OF THE MOST COMPLEX OPERATION
- ★ ALLOWS REMARKABLE CONSERVATION OF VITAL SPACE
- ★ WITHSTANDS EXTREME LIMITS OF TESTING SPECIFICATIONS
- ★ APPLICATION POSSIBILITIES AS UNLIMITED AS THE IMAGINATION



Study the following specifications with your project in mind . . . .

ASTROMATIC DIVISION
Electrosnap Corporation
4218 West Lake Street, Chicago 24, Illinois

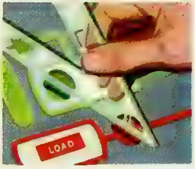
the astromatic panel concept by ELECTROSNAP

Ready now for tomorrow's higher control requirements

This new concept in panel techniques combines the latest advances in scientific, technological and psychological achievements to insure the highest possible degree of efficiency and accuracy in control or monitoring of equipment.

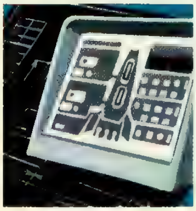
HUMAN FACTOR ENGINEERED

for highest efficiency with extreme accuracy



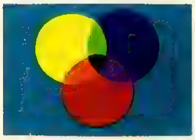
100% FLUSH PANEL . . . Eliminates protruding hardware . . . unless specified by human engineering requirements. Switching functions may be recessed, flush, or over-flush.

TRI-COLOR LIGHTS . . . Each light module contains 3 separate bulbs and circuits to permit triple indications such as GO, NO-GO and CAUTION signalling.



CONCENTRATED GROUPING OF CONTROLS...Multiple function of TRI-LITE controls permits high component density, saving from two to four times space required by ordinary panel. Permits instant visual recognition and action by operator, minimizing time-loss found in larger panels.

VERSATILE SWITCHING . . . The switching and indicating techniques are specifically designed for maximum compatibility with this advanced panel. Momentary, positive feel and alternate action switching is available.



LIMITLESS COLOR COMBINATIONS . . . The unique combination of TRILITES plus multi-color photo printing of panel allows unlimited color guidance, distinctly identifiable even by color blind.

SCHEMATIC DIAGRAMMING . . . Photo color printing of panel surface permits visual schematic diagramming. Increases speed and efficiency of operators and recognition of system indications. Reduces indoctrination period for operator training. Eliminates the written word.

PRECISION ENGINEERED

. . . Meets or exceeds most exacting specifications

SHOCK AND ABUSE TOLERANT . . . Laminated Fiberglas panel resists chipping, shattering, crazing. Coefficient of expansion identical to aluminum sub-assemblies eliminates buckling under stress or extreme cold or heat conditions.

LASTING LEGIBILITY . . . Exclusive process imbues color into Fiberglas . . . resists wear-off of legend and diagramming. Vivid colors actually photoprinted—will not chip or scratch off. Meets all requirements of MIL-P-7788 for Aircraft Cockpit Panel.

QUICK LAMP REPLACEMENT...Front panel hinged for quick access to components below, permitting 10-second bulb change if necessary.

EASY TO ALTER . . . During prototyping legend and schematic diagramming can be easily changed to visualize any new findings. Components under panel may be relocated.

VERSATILITY OF DESIGN . . . The module concept of construction makes the Astromatic panel technique extremely versatile. WHATEVER ACTION YOU DESIRE TO VISUALIZE, ASTROMATIC CAN SUBMIT A PANEL DESIGN TO SURPASS YOUR EXPECTATIONS.

MAIL COUPON BELOW FOR ADDITIONAL TECHNICAL INFORMATION . . . OR PHONE ROBERT PROVART, TECHNICAL DIRECTOR **COLLECT, VAN BUREN 6-3100**

Astromatic Division, Electrosnap Corporation
4218 W. Lake Street, Chicago 24, Illinois

Gentlemen: ☐ **Have your Design Engineer call for an appointment.**
☐ **Please count me in on any Symposium held in my area.**

Name____________________**Title**__________

Company______________________________

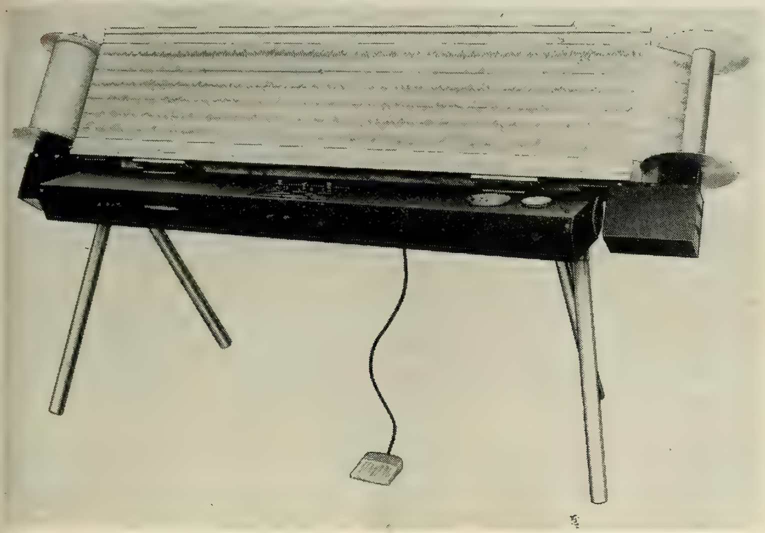
Address______________________________

City__________________**Zone**____**State**__________

ASTROMATIC DIVISION
Electrosnap Corporation
4218 W. Lake Street, Chicago 24, Illinois
VAn Buren 6-3100, TWX CG-1400

new missile products

Oscillogram Scanner Solves Data Problems



The **Gerber Scientific Instrument Co.** has designed a new model (S-10) of its oscillogram scanner to solve data reduction problems where an operator is required to scan a record over a large area.

Oscillogram strips up to 1,000 feet in length may be tracked across the 66" illuminated scanning surface. Controls are provided in a panel set flush at desk level. The operator may adjust record speed to a maximum of 100 feet per minute; select light intensity; or control record tension, direction, and braking.

The illuminated scanning surface along with the transport mechanism may be set at any convenient angle to the extent of forming a horizontal work table. Under each roller is an extremely flexible, self-contained drive system. Modular construction facilitates quick replacement of all important subassemblies.

Several reading heads, yielding digital or analogue outputs are available.

Circle No. 225 on Subscriber Service Card.

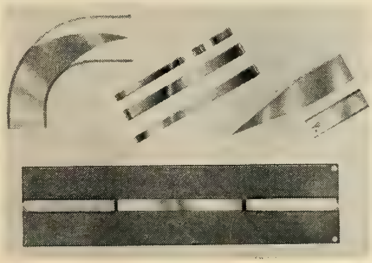
New Strip Resistor Fits Directly into Circuit

A new "two dimensional" strip resistor, which fits directly into stripline circuit and is as thin as the copper-clad conductor has been marketed by the **Filmohm Corp.**

The base of the resistor is a thin film of specially-selected natural mica. The resistance film is an alloy of pure metals, approximately 50 millionths of an inch thick and sealed with a micro-thin coating of quartz. Fired silver terminations can be supplied for dc connection of the resistor to the copper center conductor of the microstrip or stripline circuit.

The mica base is made as thick as the height of the copper conductor, that is 2 mil mica for 1.8 mil copper and 3 mil mica for 2.8 mil copper. Width is equal to the width of the copper and length is determined by requirements of electrical match, power and resistance.

A section of the stripline is etched out and the resistor is placed on the plastic dielectric between the copper conductors. Electrical contact is made by using conductive silver epoxy cement to join the silver tab on the resistor to the copper strip. Adhesive varnish is then applied over the resistor and contact areas.



The resistors can be supplied as matched loads, fixed pads, variable attenuator elements, terminations. Resistance of a few ohms to several hundred ohms can be supplied. Stripline resistors are available as straight rectangular or square sections, tapered rectangular sections for electrical match, or curved.

Circle No. 229 on Subscriber Service Card.

New Amplifiers Cut Down Drift

The **Edwin Division of Epsco, Inc.** has announced the addition of two new models to the #B-Series line of amplifiers designed for a wide variety of both rack-panel and portable oscillograph recording needs.

The highly stable 8108B amplifier

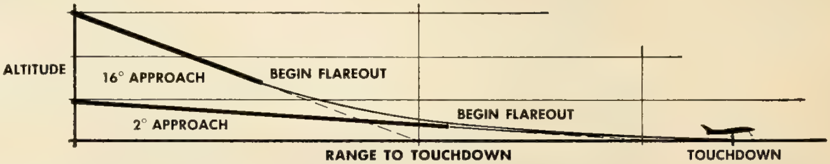
NOTE: *For additional information about any product mentioned in this section of Missiles and Rockets use the attached prepaid reply cards. Circle numbers shown on the reply card that correspond with numbers appearing beneath items described. If no circle number accompanies the article or advertisement, give page number (and advertiser's name) on line provided at bottom of the card.*

Your requests for information will be forwarded promptly to the companies concerned.

The Editor

getting back is important, too...

...With costly airplanes and missiles, the descent is just as important as the flight. Autonetics' all-weather AUTOFLARE (automatic flare control system) takes over at sinking rates as high as 100 feet per second and airspeeds as great as 250 knots...makes safe zero-zero landings truly automatic. Entirely self-contained, AUTOFLARE requires no data links or radio commands.



AUTOFLARE—adaptable to a variety of manned or unmanned airframes containing autopilots—has been proven by more than 1000 successful AUTOFLARE-controlled landings of jet fighters and supersonic missiles.

Autonetics
A DIVISION OF NORTH AMERICAN AVIATION, INC.
Downey, California

Circle No. 79 on Subscriber Service Card.

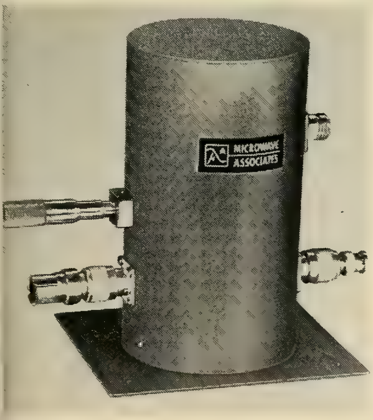
drifts less than 19 uv equivalent input per hour and will operate from 115V, ±5V power lines without additional regulation. Unusual features of the 8122B amplifier is that it drifts less than 30 uv equivalent input per hour and includes plug-in frequency compensation to extend the range of the galvanometer to 200 cycles. High input impedances permit the units to be operated with a wide variety of transducers. Both amplifiers contain an automatic signal overload protection device to prevent galvanometer burnout.

For maximum operational simplicity and an uncluttered work area, output connections are located at the rear of each amplifier, while inputs are at both the front and rear. Models are available with or without steel cabinet for portable applications.

Circle No. 226 on Subscriber Service Card.

Latest Low Noise Preamplifier Marketed

Microwave Associates, Inc. have announced the introduction of a low noise parametric RF preamplifier designated Model Number MA-1C. This Harris type preamplifier when coupled to conventional UHF receivers operating in the 350-500 mc band reportedly achieves greatly improved low noise receiver performance.



Overall receiver noise figures below 1.0 db (approximately 80° Kelvin) are achieved with bandwidths of approximately one percent throughout the specified tuning range. The preamplifier performs as a straight-through parametric low noise amplifier with RF output obtained at the signal frequency.

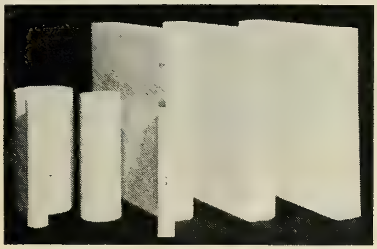
Each MA-1C provides two MA-460 varactors (one of which is a spare) and a resonant tank circuit with micrometer tuning adjustment. Type N fittings are incorporated for convenient connection of 50 ohm coax for the RF input signal, pump oscillator and output to receiver. Each is completely assembled and pre-tested for proof of performance. The preamplifier is normally used in conjunction with an existing receiving installation.

Circle No. 247 on Subscriber Service Card.

Light Ceramic Foams Withstand 1,000 Degrees

Two series of ceramic foams for electrical and electronic use, designated Eccofoam LM-43A and Eccofoam WC-8, are now available from **Emerson and Cuming, Inc.**

Both materials are light in weight and capable of use in excess of 1000°F.



Eccofoam LM-43A is supplied at dielectric constants 1.3, 1.4, 1.5 and 1.6. Dissipation factor is below 0.001. Eccofoam WC-8 is supplied at dielectric constants 1.7, 1.8, 1.9, 2.0, 2.5, 3.0, 4.0 and 5.0. Dissipation factor is well below 0.003. The Eccofoam LM-43A materials are below 20 lbs./cu. ft.; the Eccofoam WC-8 series varies from about 20 to 70 lbs./cu. ft. dependent upon dielectric constant. Flexural strength remains high, even at 1000°F. The foams can be fabricated readily with standard tools.

These ceramic foams are used in antennas, radomes, lenses and as dielectrics in microwave systems. They supplement the standard Eccofoam line of adjusted dielectric materials and extend the temperature range of use.

Circle No. 228 on Subscriber Service Card.

35-mm Camera Operates with No Blind Time

Recording 82 35-mm frames for a 55-microsecond period, the new Model 192 **Beckman & Whitley** continuous-writing framing camera is designed to accommodate magnification-velocity products up to 3 mm per microsecond, or at conventional magnification, object velocities to Mach 35.

Complementing the specifications of the widely used Model 189 framing camera, the new instrument operates

ON TARGET!
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Whether you need 400-cycle or other AC power, you will be able to perform much more accurate tests with the silent, wholly dependable Behlman INVERTRON. Now used by leading aircraft, missile, and other manufacturers throughout North America, INVERTRON offers power output ratings from milliwatts to kilowatts, fixed or variable frequencies from subsonic to supersonic, and accuracies to .001% according to model. WRITE today for further facts.
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Tell us your power problem. Let us show you how our modular construction techniques can provide you with custom instrumentation at production line prices.

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I INSTRUMENTATION WIRING
C COMPLETE INSTALLATION
B BASE COMMUNICATION SYSTEM
M MISSILE GROUND SUPPORT SYSTEMS
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484 Washington Street, Monterey, California

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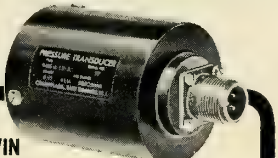

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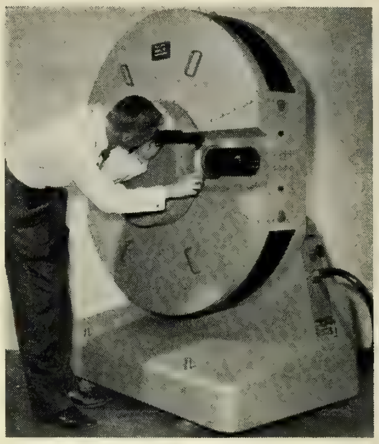
LABORATORIES, INC.
364 Glenwood Avenue, East Orange, N. J.

Circle No. 51 on Subscriber Service Card.

with no blind time, which means that it can be used to photograph high-speed events which do not lend themselves to synchronization with the position of the rotating mirror in the camera.

Because of this feature, the Model 192 is reported ideal for high-speed aerodynamic studies, for thermal-barrier studies in ballistic investigations (such as nose cone re-entry problems), for hypersonic wind tunnel instrumentation and for exploring the behavior of rocket propellants.



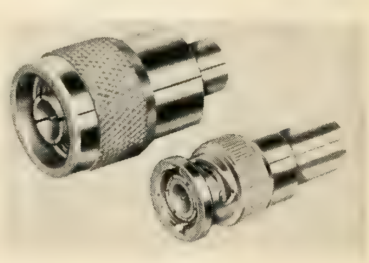
Supplied complete with operating controls, the Model 192 has boresight optics and rack-and-pinion focusing arrangements. Daylight loading and unloading are provided for with standard 35-mm film casettes.

Dimensions of the camera are 84 in. by 60 in. by 36 in. high. The camera proper weighs 1,800 pounds, lists at a standard price of $69,500.

Circle No. 230 on Subscriber Service Card.

Miniaturized Power Loads Are Made by Microlab

A new line of Coaxial Terminations has been announced by **Microlab.** These terminations are miniaturized low power loads designed to operate from dc to 10,000 mc. They are intended for airborne and other applications requiring compact, lightweight components and consist of a resistive film center conductor terminated within a carefully matched housing. They have a nominal power rating of two watts which can be increased by providing an external heat sink or forced air cooling.



Known as the TA series, the terminations are provided with either male or female connectors of type N, BNC, or TNC. Their impedance is 50 ohms and the input VSWR over the entire frequency range is 1.1 maximum.

Circle No. 231 on Subscriber Service Card.

Frequency Meter Covers Broad RF Spectrum Range

Broad RF spectrum coverage and accuracy to .005% are combined in a new frequency meter manufactured by **Divco-Wayne Electronics,** Cincinnati.

Designed for battery or power supply, the ruggedly built unit will give laboratory performance in the field, according to V. D. Heitfield, director of engineering.

Called the D-W-E 1021, the meter provides the broad spectrum coverage normally requiring three separate narrow band units. It measures frequencies from 125KC to 1000MC and generates voltages of known frequency from 125KC to well over 1000MC.

The manufacturer states that each meter is pre-conditioned in a Tenney environment chamber at temperature extremes for conditions under which it will actually operate. Accurate calibration data is supplied for 5000 dial readings, allowing unskilled operators to make accurate measurements.

Wide range frequency coverage of the D-W-E 1021, according to Heitfield, is gained by the use of three frequency ranges:

- Range A coverage is from 125 to 250KC with the second, fourth, eighth and part of the tenth harmonic series extending to 2.5MC.
- Range B coverage is from 2.5 to

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iles, Etc.)

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TO THE AIRCRAFT, MISSILE AND ROCKET INDUSTRY

Clearing's newly formed Aircraft and Missile Division is a group of engineers who specialize in solving equipment problems for the aeronautical industry. These are a selected group of Project Engineers with design background in spin forging, stretch forming, and other advanced manufacturing techniques.

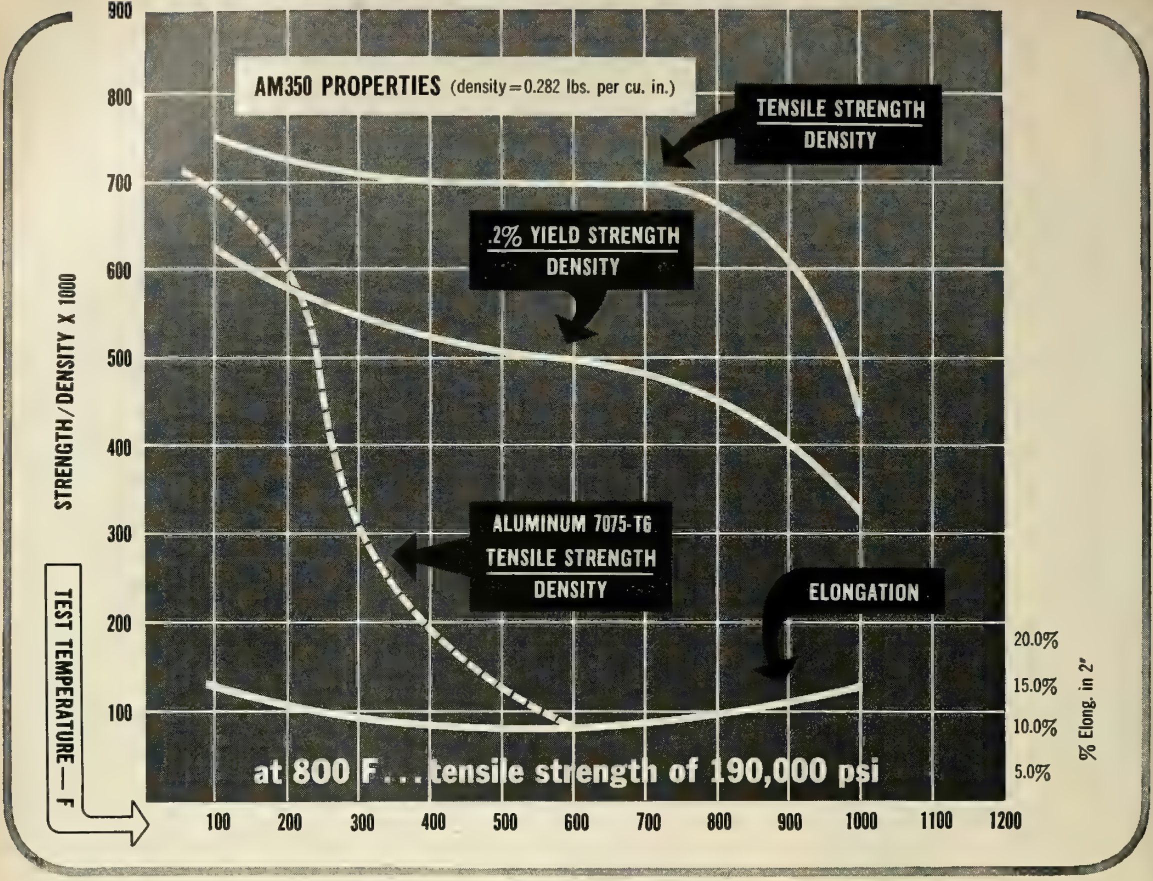
Clearing has already designed hot forming equipment, and is currently working on design concepts for other processes as shown at left. If you are faced with these or related equipment problems, call on us. Together we may be able to work out a new and improved manufacturing method for your company.

USI **Clearing** DIVISION OF U. S. INDUSTRIES, INC.

Aircraft and Missiles Division • 6160 S. Boyle Avenue • Los Angeles 58, California • LUdlow 5-2141
Main Plant: 6499 W. 65th Street, Chicago 38, Illinois • PO 7-8700

Circle No. 19 on Subscriber Service Card.

Experience**—the extra alloy in **Allegheny Stainless



at 800 F . . . tensile strength of 190,000 psi

Here are the facts on AM350 and AM355, Allegheny Ludlum's precipitation hardening stainless steels

A unique combination of highly desirable properties is the usual description of Allegheny Stainless AM350 and AM355 Steels. They combine high strength at both room and elevated temperatures, excellent corrosion resistance, ease of fabrication, low temperature heat treatment, good resistance to stress corrosion.

They are proving the answer to many problems of the air age. Airframe and other structural parts, pressure tanks, power plant components, high pressure ducting, etc. are all natural missile and supersonic aircraft applications for AM350 and AM355.

Availability: AM350, introduced several years ago, is available commercially in sheet, strip, foil, small bars and wire. AM355, best suited for heavier sections, is available in forgings, forging billets, plate, bar and wire.

Corrosion resistant: Being stainless steels, these alloys resist corrosion and oxidation. Compared to the older, more familiar stainless grades, their corrosion rating is better than the hardenable grades (chromium martensitic) but generally less than the old corrosion resistant standbys, the 18 and 8's. Stress corrosion is resisted at much higher hardness levels than with martensitic stainless.

Simple heat treatment: High strength is developed by two methods, both involving less than ordinary temperatures and minimizing oxidation and distortion problems. The most popular, and one that develops slightly better properties, is the Allegheny Ludlum developed sub-zero cooling and tempering (SCT condition). The material is held at minus 100 F for 3 hrs plus 3 hrs at 850 F. Alternate method is Double Aged (DA): 2 hrs at 1375 F plus 2 hrs at 850 F.

Easy fabrication: AM350 and AM355 can be spun, drawn, formed, machined and welded using similar procedures as with the 18-8 stainless types. In the hardened condition (SCT & DA) some forming may be done . . . 180 degree bend over a 3T radius pin. Also it can be dimpled in the hard condition to insure accurate fit-up.

For further information, see your A-L sales engineer or write for the booklet "Engineering Properties, AM350 and AM355." *Allegheny Ludlum Steel Corporation, Oliver Building, Pittsburgh 22, Pa.* Address Dept. MR-14

WSW 7327

ALLEGHENY LUDLUM

Export distribution: AIRCO INTERNATIONAL

EVERY FORM OF STAINLESS . . . EVERY HELP IN USING IT

AL

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5MC with the second, fourth, eighth and part of the thirteenth harmonic series extending up to 65MC.

Range coverage is from 65 to 130MC with second, fourth and eighth harmonic series extending up to 1000MC.

Each D-W-E 1021 is supplied in a water-tight case, with cable, connector adapter, antenna, headset, headset extension cord and AC 115/230 volt power supply.

Circle No. 232 on Subscriber Service Card.

TV Camera Designed for Rocket Engine Tests

One advantage of closed-circuit television is that the TV camera can be located where no person would dare to stand. The camera can withstand atomic radiation, heat, cold, and hazards of accidental explosion—all the while providing a close-in view of the experiment or test in progress.

Newest development is a TV camera designed specifically to resist sound levels that would shatter the hearing of a human observer. It is manufactured by the **KIN TEL Division of Cohu Electronics.**

The Model 1986CN Camera can operate in noise environments up to +145 db without an acoustical housing. With a housing, it is virtually impervious to noise of any level. It has been successfully used in sound levels above 190 db.

Immediate application for the new camera is on rocket or jet engine test stands. Previous cameras have suffered from microphonics caused by the engine's roar. The new Model 1986CN is essentially free of microphonics. It features a video-signal amplifier with subminiature tubes mounted in an unusual heat sink. The result is a dampening out of sound vibrations, plus full thermal protection.

The 1986CN Camera provides full 600-line resolution. Picture circuits have a bandwidth of 20 cps to 8 mo + ½ db, resulting in a picture of unusually high definition. Used with a KIN TEL camera control unit, the Model 1986CN automatically adjusts to changing light conditions over a 2000:1 range.

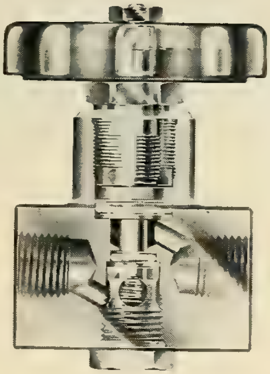
The camera weighs only seven pounds, and can be used in conjunction with pan-tilt units, auto-zoom lenses, and other TV equipment.

Circle No. 233 on Subscriber Service Card.

Telemetry Antennas Have Circular Polarization

The availability of telemetry antennas featuring circular polarization has been announced by **Technical Appliance Corp.** The antenna is designed for use in the reception of telemetering information from orbital and into-space transmitters.

The TACO G-1054 design promotes a choice of helical feeds, a 6-, 8- or 10-foot diameter parabolic reflector, and a manually-controlled mount for either ground or vehicle installation.



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PRECISION
SHUT-OFF VALVE...

featuring...

dead tight shut-off...accurate flow control...minimum restriction to flow... recommended for 0-6000 psi with virtually all non-corrosive liquids or gases...for ground support equipment and in test stands

series T900...

featuring quick-acting toggle lever handle...quick snap opens, quick snap closes, dead tight. O-Ring absorbs closing shock to system... positive locking cam holds valve open or closed...for ground support equipment and in test stands

Complete engineering data available. Write today!

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Circle Seal

James, Pond & Clark, Inc.

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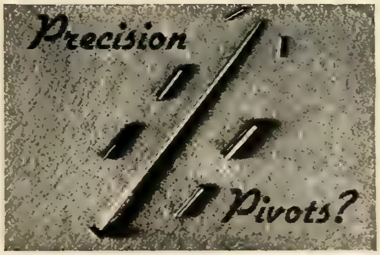

The "spike" in the center is a common pin. The others are VK precision pivots.

Call VK

Steel, chromium plated, or carbide precision pivots to .013" diameter. 1 RMS or finer surface finish. Diameter tolerance to .000010". Chamfers, radii, lapped ends, etc.

Also volume production lapping of flat or round production parts.

Send us your specifications.

The VAN KEUREN COMPANY
176 WALTHAM ST, WATERTOWN, MASS.

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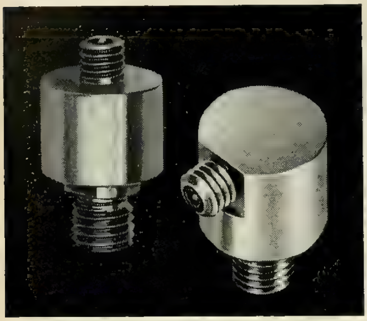


Avoid false test results with GLENNITE internally ungrounded accelerometers

Now you can avoid one of the major causes of false test results — spurious "ground loop" voltages — by using *internally ungrounded* GLENNITE accelerometers.

These units contain sensitive seismic elements *internally* insulated from the mounting stud by rugged ceramic insulation. You can employ a *single point ground* at the data handling or recording equipment by using a combination of these accelerometers with ungrounded GLENNITE amplifiers and filters.

GLENNITE accelerometers are available in uni- and triaxial models — wide acceleration and temperature ranges.

A complete line of associated ungrounded electronic equipment includes filters, amplifiers, connectors and other related units.

For complete data on Gulton instrumentation systems — grounded or ungrounded — contact your local Gulton representative or write us direct.

Call in Gulton

From transducer to readout, Gulton is capable of meeting all your instrumentation needs. If you have a measurement problem, why not call in a Gulton Instrumentation Engineer. His broad experience in shock and vibration measurement can prove invaluable to you.

GULTON INSTRUMENTATION DIVISION

Gulton Industries, Inc.
Metuchen,
New Jersey

Circle No. 55 on Subscriber Service Card.

Gain of the antennas is in the area of 23 to 26 db over an isotropic source, while the nominal beam width is 8° to 14° depending on antenna size. Frequency range of the new antenna is 940-980 MC, and is available on special order for other frequencies. VSWR of the complete antenna is less than 1.3.

The antenna is completely balanced, permitting easy and accurate manual orientation. It has an azimuth adjustment of 360° and an elevation adjustment of 0-90°. Positioning is accomplished by means of a hand-operated, positive, clamp.

Degree markers are provided for both azimuth and elevation readings.

Transmission line feed is through a type N connector with a terminal impedance of 50 ohms.

In addition to orbital and into-space telemetering, the TACO Model G-1054 may be mounted on top of a van or trailer and effectively used for TV-Studio Transmitter Links (STLT) by feeding the dish with a 1990-2110 MC feed.

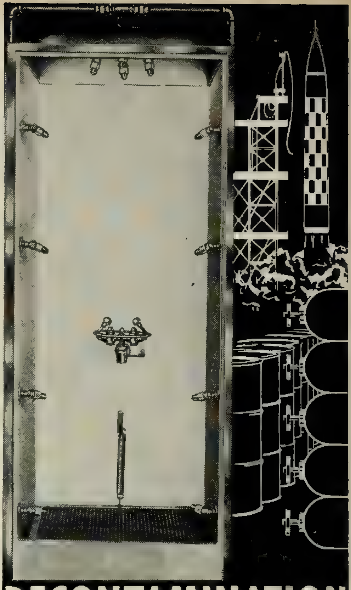
Circle No. 234 on Subscriber Service Card.

Oscillographs Developed for High Speed Testing

The **Heiland Division of Minneapolis-Honeywell Regulator Co.** has developed two new models in its 906 series of direct-recording oscillographs that provide higher recording frequencies and increased channel capacities.

The new Visicorders, designed to monitor and record a variety of electrical and mechanical phenomena during high-speed scientific and industrial testing operations, include:

The 906A-1, which features high-sensitivity miniature plug-in galvanometers and magnet assembly. This use of subminiature galvanometers permits 14



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is made of durable, lightweight reinforced fiberglass plastic, and features Haws Eye-Face Wash Fountain, eight lateral body sprays and overhead spray unit. **All are simultaneously activated by weight on the base-mounted foot treadle!** Contaminated victims are instantly "covered" with water that floats away foreign matter from body and clothing.

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		missile type										service use						propulsion							guidance					ground support
		Surface-Surface	Air-Surface	Air-Air	Surface-Air	ICBM	IRBM	IGBM	Drone	Tactical	Unknown	Army Ordnance	USAF	NAVY	Army Sig. Corps	Bur. Aeronautics	Unknown	Liq. Fuel Rocket	Solid Fuel Rocket	Booster	Ram Jet	Turbo Prop	Gas Turbine	Unknown	Radar	Inertial	Infra Red	Radio	Unknown	
cooling systems	Mechanical Refrigeration				■	■							■	■						■	■				■			■		
	Expendable Refrigeration	■			■	■							■											■					■	
	Cryogenic					■							■			■		■									■			■
	Heat Transport								■			■	■											■					■	■
	Console Cooling	■		■	■		■			■		■	■			■		■	■						■	■				
	Evaporative	■			■				■				■									■						■		
heat exchangers	Liquid/Air	■	■		■				■				■		■			■		■	■				■	■		■		
	Ammonia/Glycol	■											■											■					■	
	Liquid/Gas										■						■				■								■	
	Evaporative		■										■											■					■	
	Liquid/Liquid	■	■		■								■	■						■			■			■				■
	Liquid Ammonia/Liq. Oxygen					■							■					■							■					
	Hot Gas/Nitrogen Tetroxide				■									■										■					■	
	Ammonia/Air				■								■								■				■					
	Cold Plate	■		■										■		■			■						■	■				
valves	Rupture		■		■									■				■							■					
	Explosive				■									■										■					■	
	Bleed		■			■							■	■										■					■	
	Bypass			■	■	■			■				■									■						■		■
	Temperature Control										■						■							■					■	
	Pressure Control										■						■							■					■	
	Solenoid		■		■								■								■	■				■		■		
	Thermostatic										■						■							■					■	
hand pumps																														■
oil tanks	All-Attitude	■	■	■	■			■	■				■	■	■			■				■						■		

The achievement chart proves UAP's extensive experience and ability in designing and building electronic cooling systems, components and flow control devices. Whether your electronic cooling problem involves airframe, guidance, propulsion or ground control equipment, UAP has the technical know-how to solve it! Call your UAP Contractual Engineering Office today!

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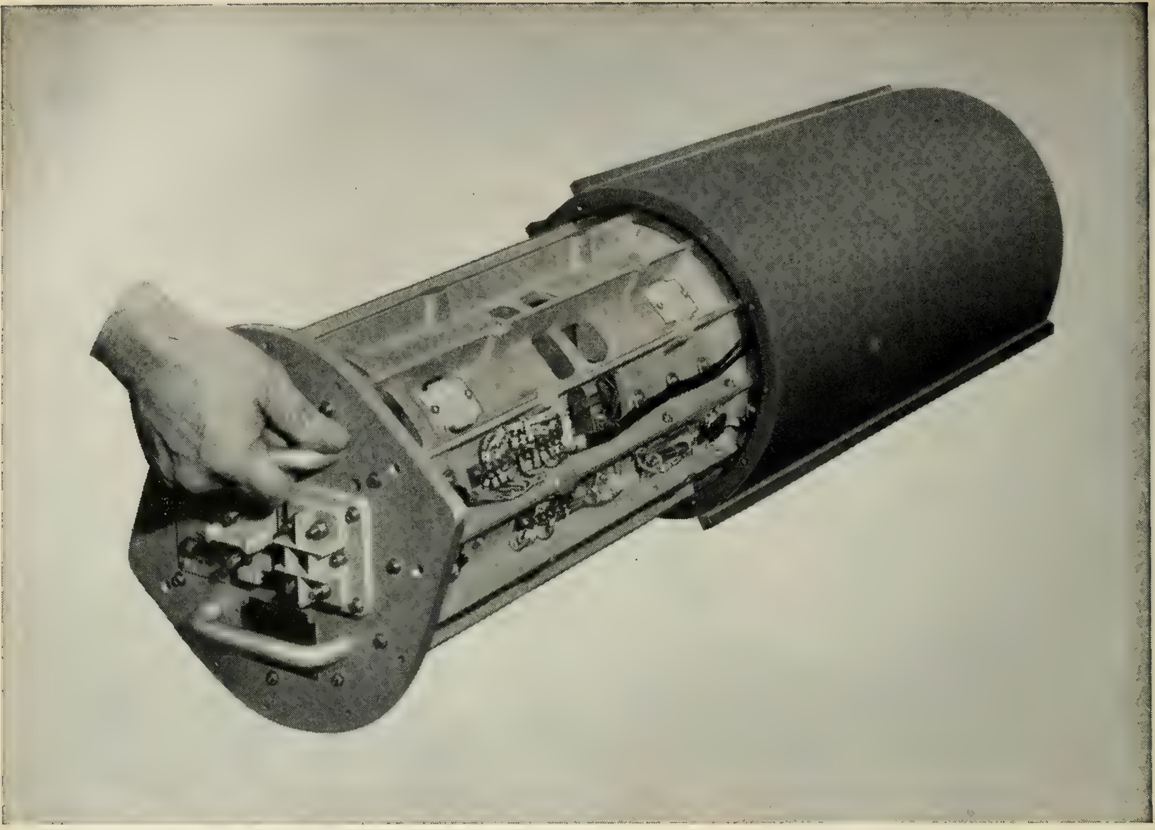

NEW! BENDIX CANISTERED INVERTERS

Withstand the Effects of Temperature, Vibration and Acceleration at Blast-off and Will Function Perfectly at Any Altitude, Including Outer Space

Bendix Canistered Inverters, environment-free and completely sealed, are now in production for the Atlas and Thor missiles. Designed for dependable and efficient operation, Bendix Canistered Inverters are completely sealed against the effects of altitude and can withstand conditions from sea level to outer space.

Cooling techniques employed enable these units to provide full-rated output throughout the flight without external cooling. Both voltage and frequency regulation are accomplished by static, magnetic amplifier-type regulators. Since these regulators have no moving parts, output voltage and frequency are not affected by vibration and shock. The total harmonic content of the output voltage per phase is less than 5%.

Bendix Canistered Inverters are the product of years of development and experience in manufacturing electrical power equipment for aircraft and missiles. They are engineered to meet the strenuous requirements in performance and reliability called for in today's (and tomorrow's) missiles. For more detailed information write to RED BANK DIVISION OF BENDIX AVIATION CORPORATION, EATONTOWN, NEW JERSEY.

West Coast Sales and Service: 117 E. Providencia Ave., Burbank, Calif. Canadian Distributor: Aviation Electric, Ltd., P. O. Box 6102, Montreal, P. Q. Export Sales and Service: Bendix International Division, 205 E. 42nd St., New York 17, N. Y.

Red Bank Division **Bendix** AVIATION CORPORATION

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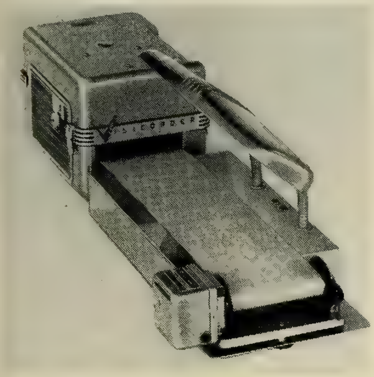
channels of data to be directly recorded at frequencies from DC to 5,000 cps, and

The 906A-2, with "solid-frame" galvanometers and magnet bank, provides for eight-channel recording at frequencies from DC to 2,000 cps.

The new timing unit is a separately-housed multivibrator oscillator that provides short, accurately-spaced pulses to timing galvanometers of .01, 0.1 or 1.0 seconds. Pulse characteristics are such that, with the timing signal applied to two 3,300-cycle natural frequency galvanometers, full width time lines will result.



Legible records within a few seconds are possible with Heiland's bench-mounted unit that latensifies and spools Visicorder records. The unit consists of a record takeup unit with drive motor and removable spool.

The motor automatically adjusts to all standard paper speeds from .2 inch per hour to 500 inches per second, with capacity of 100 feet of six-inch Visicorder paper.

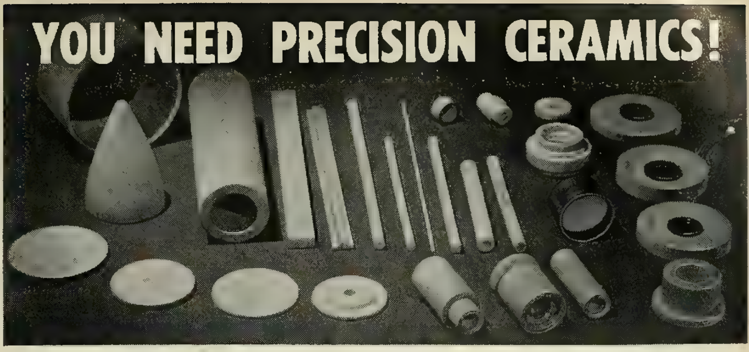
The latensifier, which connects to the Visicorder for power and is equipped with a receptacle for remote operation of both units, is mounted on a platform that is equipped with two fluorescent lamps over the viewing surface.

Circle No. 235 on Subscriber Service Card.

Cartridge Type Heater Unit Now in Production

Tektron Instrument Co., has announced the stock production of a new cartridge type heater unit.

Believed to be the smallest of its type available, the unit measures .250 inch in diameter, with an overall length of 1.5 inches. The heating element is located within one inch of the inserted end. Electrical specifications are: 37 watts, 28 volts, cold resistance 21 ohms. The casing is stainless steel. They are



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Berlox (pure BeO) was specifically developed with properties for high resistance to thermal shock, excellent chemical stability and extremely high dielectric strength. A full line of products including: rods, bars, plates, tubes, radomes and nose cones is available from National Beryllia Corporation.

These products are also available in other pure oxides such as: Alox (AL_2O_3); Zirnox (ZrO_2); Thorox (TH O_2); Magnox (MgO) and metalo-ceramics. Special shapes and sizes are available to solve any critical temperature problem.

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available from stock in quantities from one to 500.

This unit is now being used in missile engines to heat the liquid oxygen pump lubricant. Many other uses are possible, including high altitude instrument and hydraulic temperature control, laboratory and instrument temperature control.

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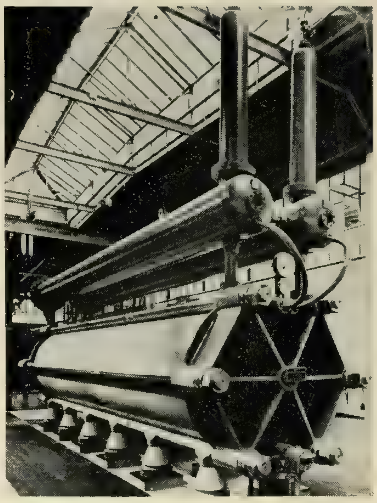
Pressure Electrolysis Produces Hydrogen, Oxygen



Highest purity industrial hydrogen and oxygen now can be economically produced by means of pressure electrolysis. The process is made possible by availability of the Zdansky-Lonza Pressure Electrolyzer, developed by Lurgi of Frankfurt, West Germany, and offered throughout the United States and Canada by **Winfield Equipment Co.**

Compared with earlier and conventional electrolyzers, which operate at atmospheric pressure, the Zdansky-Lonza unit utilizes tremendously high pressure generated without use of compressors—30 atmosphere gauge pressure on an industrial scale. Basically, use of high pressure, rather than atmospheric pressure, decreases cell-voltage requirements corresponding to the specific power consumption and power consumption is reduced bringing about a savings of 20% in energy.

Furthermore, 50% savings in equipment floor space is effected. These benefits, plus elimination of need for additional purification processes, lower operating and maintenance costs. The only labor required is reading of gauges periodically.

Purity obtained is 99.9% for hydrogen and about 99.8% for oxygen. Thus they are ready to use, or sell, at the end of this self-contained process.

Circle No. 237 on Subscriber Service Card.

Electromagnets Controlled by Unit's Error Signals

A new nuclear magnetic resonance field control unit, the model FC-501, has been made available by **Harvey-Wells Electronics Inc.**

The new instrument is designed to provide a means of precise regulation of electromagnets by producing an error signal, derived from the field under control, suitable for closed-loop regulation of the magnet power supply.

The range of the FC-501 is 310 to 20,000 gauss with standard probes. For control of fields out of this range, special probes are available.

The unit consists of three interconnected parts: (1) probe, (2) oscillator, (3) field control unit. The latter con-

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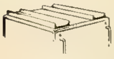

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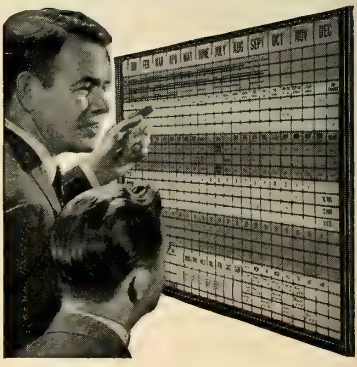

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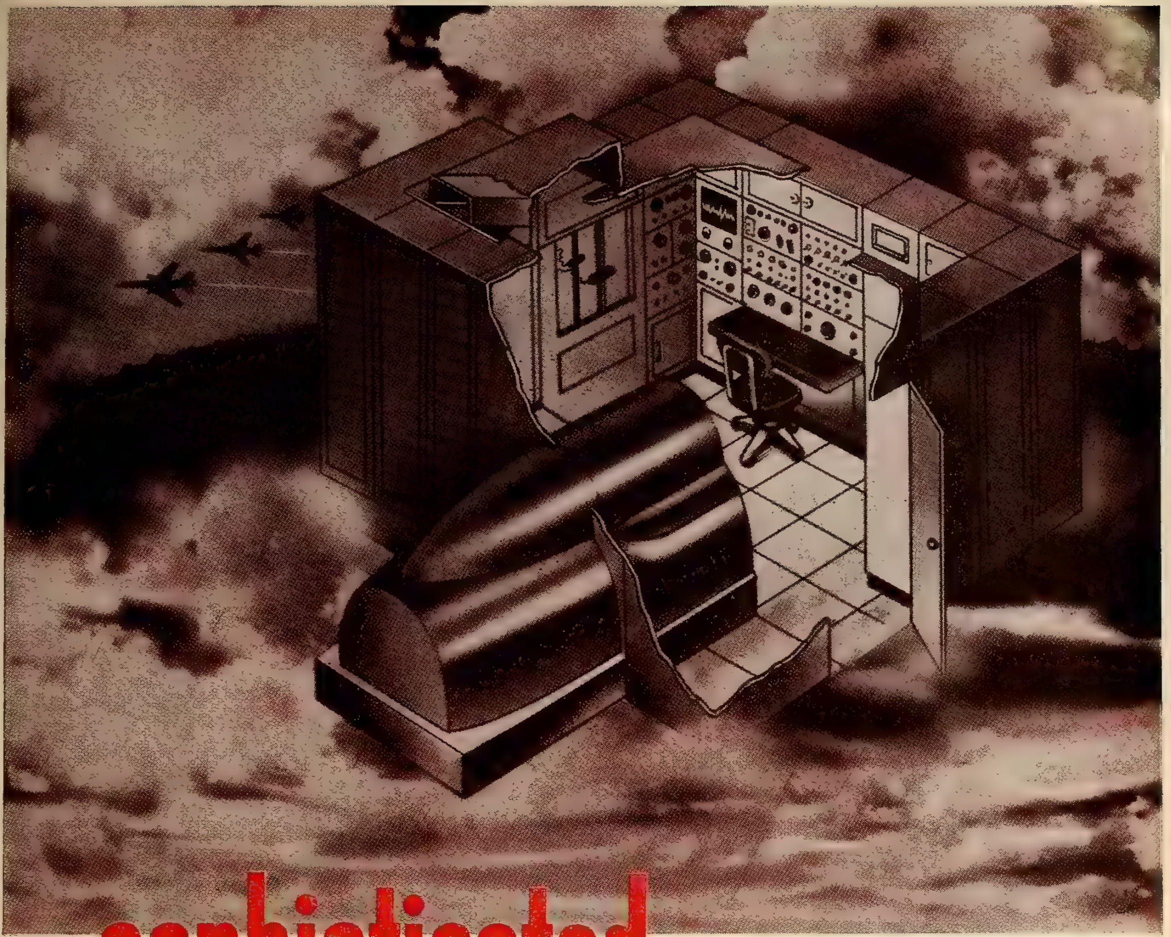

sophisticated mission training

THE F-105-D FLIGHT SIMULATOR—BEING HUMAN ENGINEERED, DESIGNED AND BUILT BY ERCO PROVIDES COMPLETE, RELIABLE, EFFECTIVE TRAINING FOR THE ENTIRE MISSION PROFILE OF THE LATEST AIR FORCE ADVERSE WEATHER AIRCRAFT.

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Automatic Self-Checking System (aural-optical) provides component failure indication by general area and exact location. The simulator is operative in a matter of minutes.

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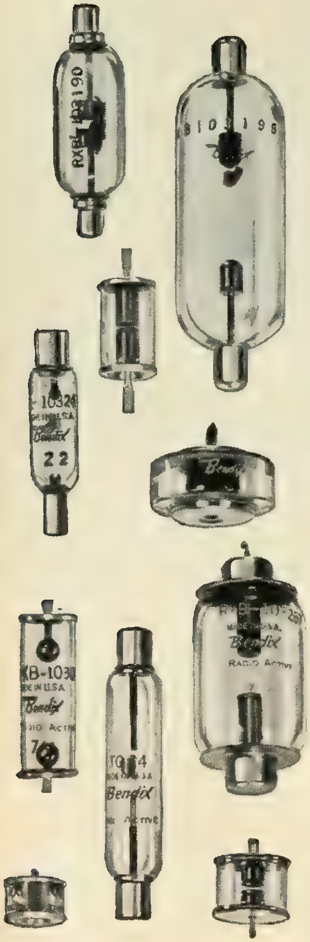
HOW
BENDIX SPARK GAPS
CAN PROTECT
YOUR RADAR EQUIPMENT



Bendix Red Bank "Spark Gap" Tubes are specially designed to do two big jobs in electronic circuits.

First, to act as a *"triggering" switch*—as on jet ignition systems. Here, Bendix* Spark Gaps pass high currents with relatively low voltage drop and have the advantage of being able to handle high voltages in small space. Further, these tubes can be made insensitive to ambient temperature variations and are not normally affected by pressure, altitude, or humidity changes.

The second function of Bendix Spark Gaps is as a *protective element*—guarding radar equipment against voltage overload, to name one example. Here, Bendix Spark Gaps keep high voltage surges from getting through to damage circuit components.

Our design and manufacturing experience with spark gap tubes is extremely broad. If our extensive line of these tubes . . . ranging from 750V to 50KV in DC breakdown voltages . . . does not already contain a type to fit your needs, we are in a position to design one to handle the job with the exact degree of efficiency that you require.

To find out more about what we can do to help you with your spark gap problems, get in touch with RED BANK DIVISION, BENDIX AVIATION CORPORATION, EATONTOWN, NEW JERSEY.

* TRADEMARK

West Coast Sales and Service: 117 E. Providencia Ave., Burbank, Calif.
Canadian Affiliate: Computing Devices of Canada, Ltd., P. O. Box 508, Ottawa 4, Ont.
Export Sales & Service: Bendix International, 205 E. 42nd St., New York 17, N. Y.

Red Bank Division Bendix AVIATION CORPORATION

Circle No. 61 on Subscriber Service Card.

sists of a power supply, lock-in amplifier and modulator. The company says the oscillator is stable to greater than ten parts in a million and even greater stability can be obtained by cohering it to an external frequency standard.

The modulation sweep range is zero to 20 gauss. Increased modulation facilitates the location of resonance and a modulation control allows decrease of modulation to optimize field control action.

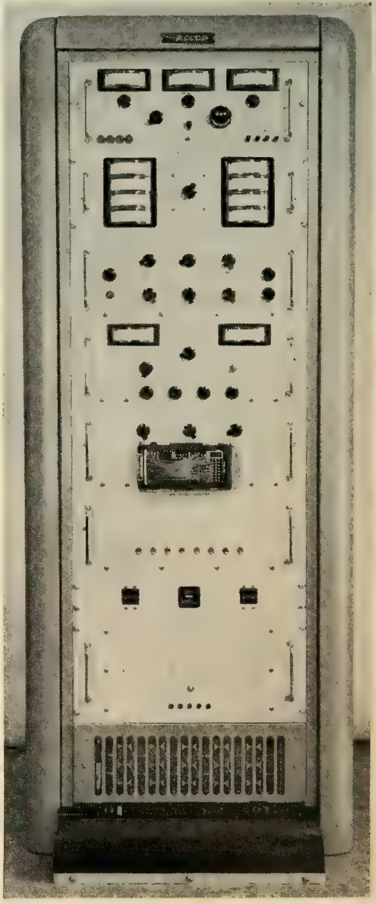
The unit operates at 115 volts, 60 cycles at 2.5 amps. Both the oscillator and field control unit are compactly designed and weigh 45 lbs.

Circle No. 231 on Subscriber Service Card.

Decommutation Equipment Handles Sampling Rates

New telemetry decommutation equipment that can handle sampling rates from 24 to 3600 p.p.s. in both Pulse Amplitude (PAM) and Pulse Width (PWM) doding is now in production at the Applied Science Corp. of Princeton (ASCOP).

Besides the dual PAM/PWM ca-



progress report on Aeronutronic

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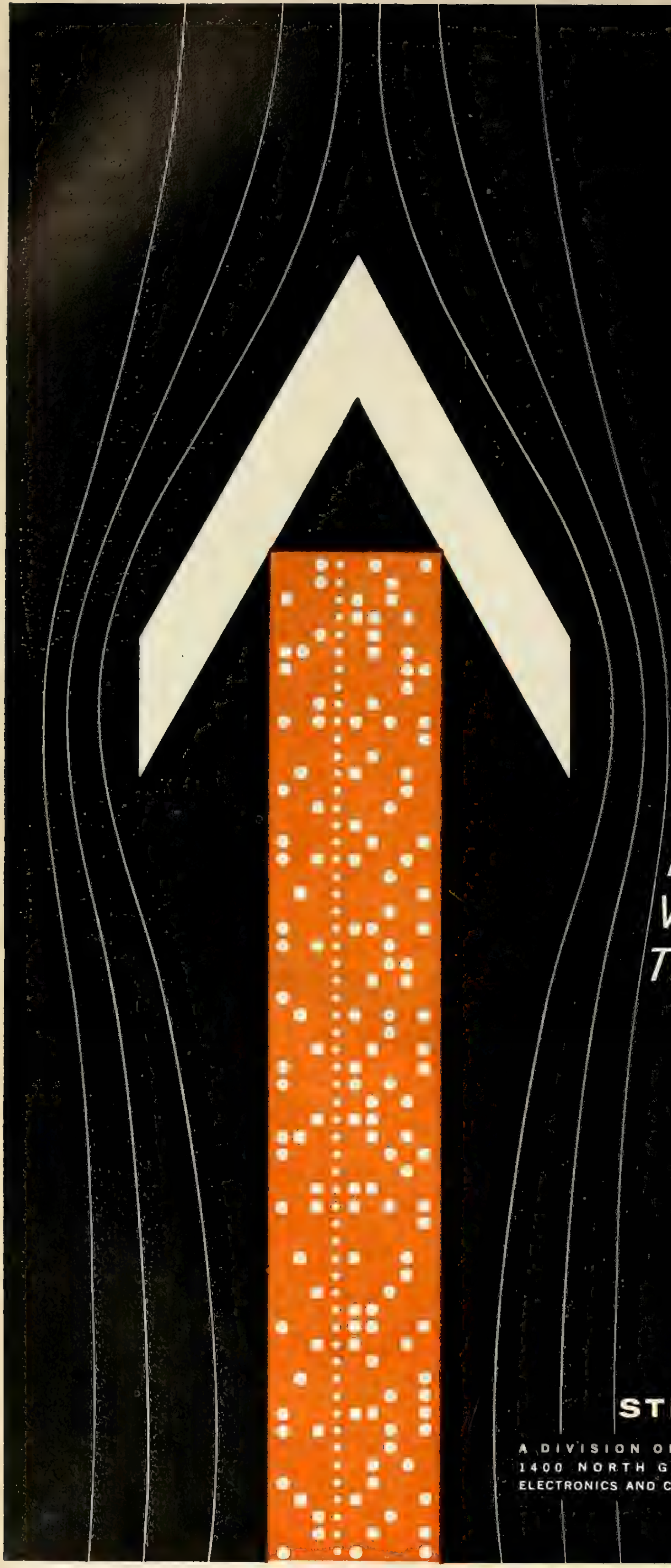

A TALENT FOR WEAPONS TEST EQUIPMENT

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ELECTRONICS AND COMMUNICATION FOR HOME, INDUSTRY AND DEFENSE

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Critical problems in weapons system testing: the reduction of test time with increased test reliability . . . the reduction of equipment costs with increased test flexibility.

The search for a system meeting these requirements has led to the SCATE concept of standardized block design.

SCATE—Stromberg-Carlson Automatic Test Equipment—embodies existing hardware as a nucleus.

Implementation with special stimulus generators and response monitors rounds out the SCATE system, which meets the testing needs of any weapons system, component, or sub-assembly . . .

and is flexible, self-checking, self-calibrating . . . brings lower cost, new speed and reliability to weapons testing.

Brochure available on request.

S-C STROMBERG-CARLSON | GD GENERAL DYNAMICS

pacity and the wide sampling rate capability, the new equipment also features long term system accuracy of better than ±0.5%, including any system non-linearity and drifts and an undecommutated but thoroughly corrected output for convenience in digitizing.

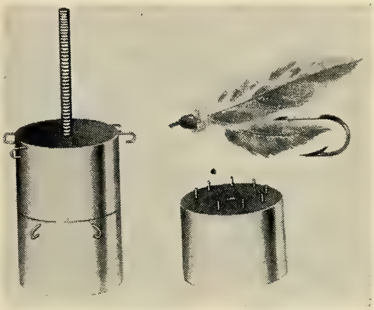
The sampling rate capability makes the new equipment compatible with both standard IRIG configurations and a large number of non-standard rates.

The new M-Series design emphasizes flexible modularization. Miniature tubes and components are mounted in plug-in modules which are standard throughout each system. This permits rapid plug-in replacement of modules. New M-Series chassis have a 7-inch modular front panel and can be mounted in all standard equipment racks.

Circle No. 243 on Subscriber Service Card.

Unit Features Optimum Temperature Stability

Arnold Magnetics Corp. has announced the addition of a temperature-stabilized type to its line of small-size toroidal inductors. The unit features optimum temperature stability across the military temperature environment range of –55° to –71°C. Inductance can be as little as plus or minus 0.25% change in this range.



The unit uses a stabilized core, and is fully encapsulated with special materials to acquire the desired temperature stability. Built to withstand extreme shock and high temperature, it meets the specifications of MIL-E-5272A and MIL-T-27A.

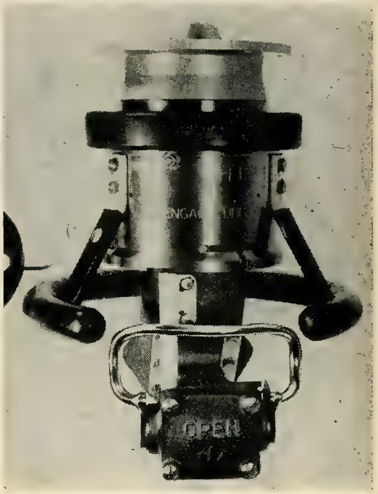
Designated as "S" type, this stabilized version is now available in all series of Arnold inductors, with inductance values ranging from 0.1 millihenry to 17 henries, and with useful frequency ranges from 60 cycles to 500 kilocycles.

The units are designed for printed circuit boards, or stacking on single screw for chassis mounting.

Circle No. 245 on Subscriber Service Card.

New Hydrogen Peroxide Nozzle Is Non-Corrosive

A new self-sealing, high flow rate hydrogen peroxide nozzle and adapter for servicing aircraft or missiles using hydrogen peroxide as an oxidizer has been announced by **Flight Refueling Inc.**



Safety requires the nozzle to be manually locked to the adapter before the internal valves can be actuated and, collaterally, the internal valves must be completely closed before disengagement.

Another important feature is that working parts are fitted externally and do not come in contact with the fluid, eliminating the possibility of corrosion.

Circle No. 227 on Subscriber Service Card.

Test Stand Filter Handles up to 5,000 psi

Filter capable of handling systems with working pressures of 3,000 and 5,000 psi, a new line of high-pressure filters for hydraulic fluids, air, liquids and industrial fluids is now available.

Designated as Model 13460 by the manufacturer—**Bendix Aviation Corp.**—these units may be applied to missile hydraulic and pneumatic test stands, and can also be used to remove contaminants from chemical and related industrial fluid processing systems. The units also provide protection for hydraulic and pneumatic control systems in machinery.

The filters are available in eight sizes, with particle ratings from 5 to 250 microns. In fluid contamination control, maximum particle size can be limited to 15 microns.

Circle No. 246 on Subscriber Service Card.

letters

Launching Ratio

To the Editor:

As a regular reader of MISSILES & ROCKETS which to me has often been a source of first class information, I was somewhat astonished to read an article by Alfred J. Zaehringer (m/r, Dec. 15), that the ratio launching weight/payload of Russian satellite rockets is supposed to be 1000:1.

As evidence against this supposition, I point to an article published by U. A. Pobiedonosstsev in Priroda which seems to give details of the launching of *Sputnik II*. Pobiedonosstsev's figures are:

Launching weight, 111.6 metric tons; four steps; payload, 300 kgs; dry weight of step four, 216 kgs; ratio, 372:1.

E. Jaeger, ing. diplome
6, Hettlerstrasse
Weiningen, ZH Switzerland

Editor Zaehringer replies:

I did not imply that Soviet Sputniki has ratios greater than 1000:1. My article dealt with the possible lash-up of standard, heavy, artillery rockets to provide for "quick" satellites for the satellite nations. In this respect, the improvization of such satellites would be done with heavy, relatively inefficient hardware—much like the American Explorer vehicle.

I have not seen any figures on vehicle weights for the Soviet Sputniki. Perhaps your figure is correct. However I am inclined to use more conservative figures. Kölle of Germany estimates that the launching weight of Sputnik II was something like 132,500 kg instead of the 116,000 kg figure you mentioned. You have to be very careful in analyzing what the Soviets say—especially if it is indirect such as the Priroda statement.

My figures indicate that the ratio of the launching weight to payload weight of Sputnik II was between 616: and 1380:1.

Space and the World

Professor Teofilo M. Tabanera, vice-president of the International Astronautical Federation and South America's leading exponent of rocketry and astronautics, has written the following letter to m/r expressing a viewpoint which may be widespread among world scientists. It is reproduced below (somewhat condensed for reasons of space). We would like to hear from others interested in world astronautics.

It has been over a year now since one of the most remarkable events in recorded history occurred, and the word *Sputnik* has become firmly established in our everyday vocabulary . . . Successful artificial satellites represent the starting point of man's greatest adventure, flight into space.

Nearly four years have passed since announcement of the U.S. *Vanguard* program and the part it would play in the International Geophysical Year. It was emphasized that the outcome of satellite and space research would be made known to scientists of all the participating nations of the world, Russia included.

Shortly afterwards the USSR announced a similar program, and during 1958 we saw them place three satellites whirling in space. Rocketry is being developed both by the Russians and the Americans on a colossal scale, and elaborate projects, including manned interplanetary flights are widely predicted.

But what is the rest of the world doing? Are we, who are neither Russians nor North Americans, going to take part in this great enterprise or are we to remain mere spectators? So far, we have done little but watch in awe . . .

Nearly five hundred years ago mankind started another great enterprise, the discovery and conquest of another new world. Two nations, Spain and Portugal, almost exclusively undertook the early explorations. At first the rest of the world showed very little interest in this important event . . .

Now we are starting on another great enterprise, far greater in magnitude and more magnificent in concept . . . Again we find two major nations involved, one representing old Eurasia, the other the young, striving American civilization. But there is a more fundamental difference between the two undertakings: the former's new world explorations were not carried out in a spectacular way; they went by quietly and there was no pretense of having other nations initially share in them. Today's enterprise has commenced quite differently: it is spectacular and noisy, and it is reluctant to allow the rest of the world to share in its development.

The U.S. and the USSR have been working on rocketry and astronautics in a state of practical isolation from each other, and from the rest of the world. All research and tests have been surrounded by utmost secrecy . . .

What has been the effect of all the secrecy? First, the other 98 nations of the world have been denied much valuable information and second, the two giant powers possessing it have kept it from each other.

The melancholy result has been that both countries . . . have had to invest more energy, more time and more money in researching the same area, thereby doubling their own efforts.

Almost immediately following the Russian satellite achievements, the Americans rushed to at least partially improve their situation by putting up a series of small *Explorer* satellites. Externally, it seemed likely that they would reach an agreement with Great Britain to carry out certain joint tasks, and already *Thor* and other missiles have been made available to them.

Thus, a gap has been opened and a rather tardy effort is being made to correct a great mistake, the negative results of which are evident. But only partially may it be corrected. The walls are closing in again and a new lunar exploration stage is to start.

The mistake lies in the barrier, and this mistake of discrimination is based on another mistake of appreciation—believing that only the scientists shut in behind the artificially erected walls can create new things. Luckily, this is wrong, for the genius or the intellectually-gifted man may arise anywhere . . .

When America was discovered and "colonized," the world made the mistake of not participating, leaving it for a long time in the hands of only two countries. Five hundred years ago this could be considered natural. But when we begin the exploration of the cosmos a large part of the world should not be put aside, remaining a mere spectator . . . That outer space does not belong, and should not belong to any group of men (no matter how well-meaning it may be) seems quite obvious. And it does not belong to mankind either. It does not belong to anybody, particularly nor generally. All men are entitled to take part in this great enterprise . . . And all men have not only the right but the duty to do so . . .

We have an International Astronautical Federation, now nine years old, numbering among its members the most important astronautical and rocket societies in the entire world, East and West alike. The IAF (whose current president is an American and one of whose vice presidents is a Russian) assuredly is the qualified organization to look for the best solution of this complex problem. It is very likely that, in the long run, the world will have to get together in developing the space age, if for no other reason than to avoid mutual destruction. Why not at least experiment through the IAF now? . . .

Ing. Teofilo M. Tabanera
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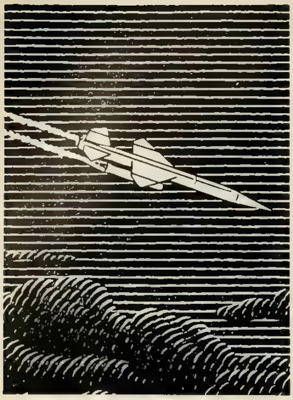

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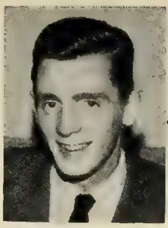


keeping track

by Peer Fossen

It looks like everybody must have his say in the discussion over whether the Russian moon rocket was a hoax, a favorite topic in Washington these days. Some sources base the hoax reports on briefings given to Congressional leaders by Central Intelligence Director Allen W. Dulles. After one of these sessions, Sen. Styles Bridges (R-N.H.) reportedly said there was something to the stories, but he declined to elaborate "because of the classified nature of the meeting."

A few days later, however, Bridges declared on ABC-TV's College News Conference that "there is nothing that any nation has in existence today that will prove this last *Lunik* or "Sunik" actually reached the sun and went into orbit around the sun. "There is no tracking operation. It may be a huge propaganda scheme. We know they launched the huge missile and that it went to a great height. For all we know, it may have disintegrated, or it may still be going around the sun. But there is no proof," he said.

Regardless of the Senator's statement, there are several reports from various sources indicating that the Russian space vehicle was actually tracked in the U.S.

One of the first such reports came from JPL's Dr. William H. Pickering who said that the United States apparently "tracked" the cosmic rocket as it passed beyond the moon.

According to Pickering, the Army's Goldstone facility picked up the signal on Sunday, Jan. 4, about two days after the Kremlin announced the launching, and after earlier tracking efforts had failed.

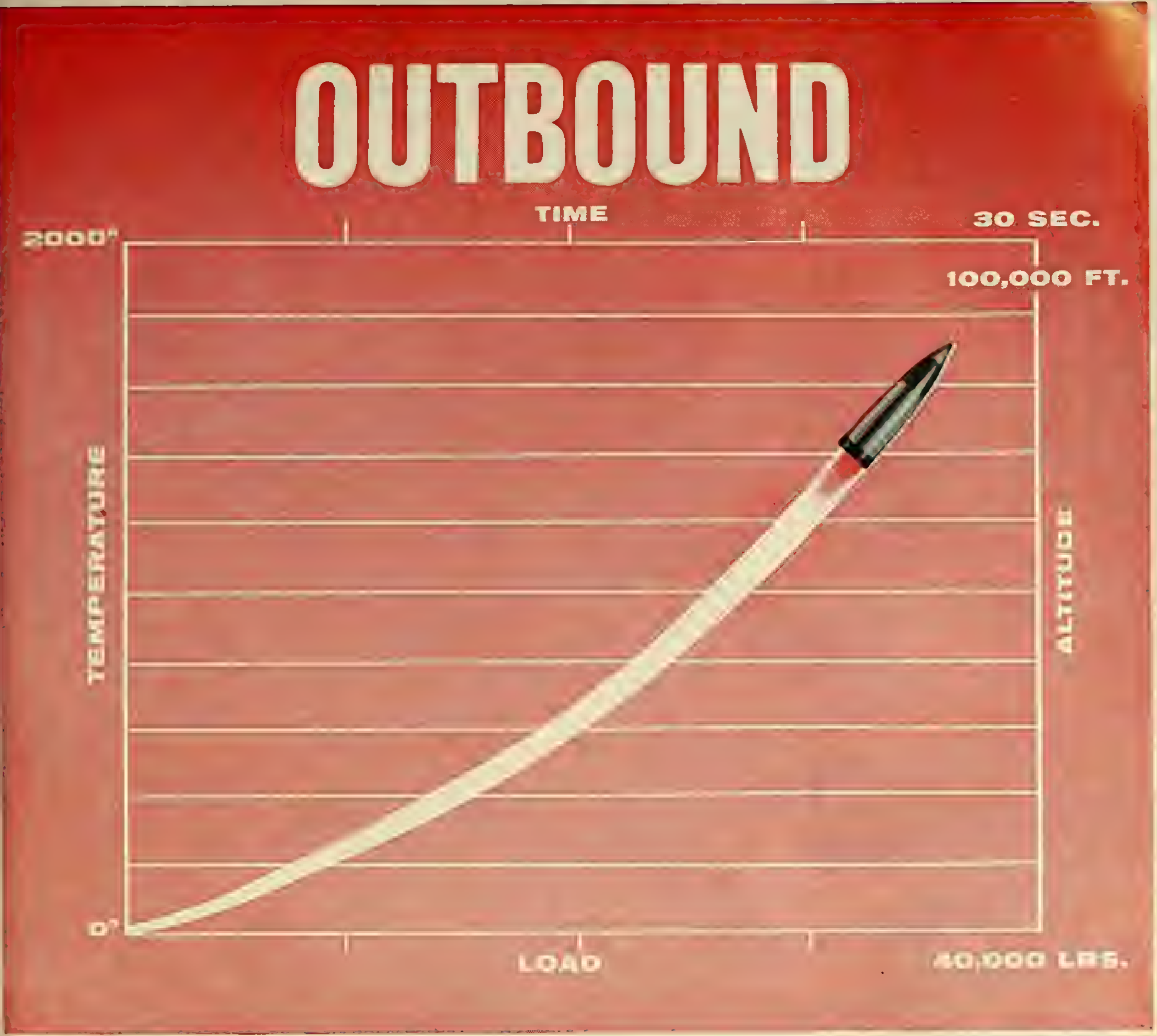
He said the signals came from the region west of the moon, and that the angle between the moon and the signal source increased with time, indicating that the signal source had passed beyond the moon. The Goldstone facilities had to be modified substantially before the tracking could take place since the frequencies reported to be in use by the Russians were much lower than the frequency at which the station was originally set up to operate, (960 megacycles for *Pioneer III*). The Goldstone tracking is supposedly the first outside Russia.

Dr. Pickering carefully avoided saying whether the signals picked up at Goldstone came from the Russian vehicle, admitting only that the observed data—as far as time and space was concerned—was about what could be expected on the basis of Soviet announcements—after the vehicle passed the moon.

Other facilities reported to have been involved in the *Lunik* tracking include Ft. Monmouth, Millstone, Cape Canaveral, and Cambridge, but the authorities have not submitted any definite statement whether these facilities actually did any tracking.

An interesting *Lunik* story circulating in Washington is that the Pentagon clamped down on the release of information by direct order of the President. The story has it that Eisenhower blew his top after the Pentagon had okayed a congratulatory message to the Russians before anyone knew for sure that their announced space stunt was not a hoax.

University of Michigan scientists have proposed a radar space observatory containing a nuclear power source to supply electrical energy. It would be used to determine the best location for landing on the moon to avoid sinking in the lunar dust. The university indicates that the space vehicle could be built with "on-the-shelf" equipment, but this does not quite add up. They have estimated the gross weight of the rocket to 500,000 pounds with about 750,000 pounds of thrust required for the first stage. It doesn't seem possible that we have that kind of equipment "on the shelf."



Second by second, higher-order performance is required of today's missile design—even as temperatures and loads are on the increase geometrically.

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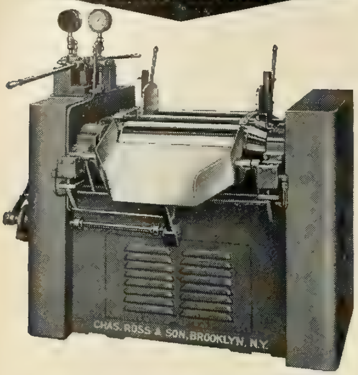

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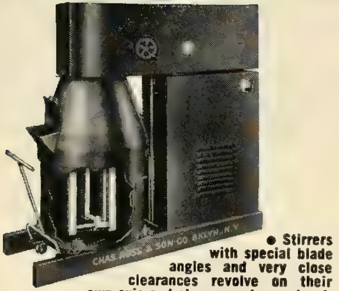

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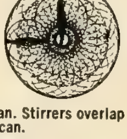

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west coast industry

by Fred S. Hunter

Lockheed Aircraft Corporation is completing plans for establishing a new electronics division to deepen its penetration in this field. Lockheed's Chairman Robert E. Gross has long felt the need to build a well-rounded electronics capability in the company to improve its potential in managing complete weapons systems.

In 1957, Lockheed formed a diversification task force to study mergers or acquisition of other companies that might help bring this about. Some actual negotiations were started. Lockheed is not giving up this hunt for a suitable company, but it has decided to wait no longer for another company to come along.

Lockheed already has a wide range of experience and know-how in electronics through the work of its Missiles and Space Division; its highly-instrumented, early-warning aircraft; its radar-packed patrol planes and similar efforts. The character of Lockheed's divisional setup also makes creation of a new division for electronics a logical move for expansion in a new growth area. Lockheed should be able to work up quite a race between its Missiles and Space Division and a separate electronics division.

And speaking of electronics, here is another indication of the way the wind is blowing. Forecasts for Ryan Aeronautical Company, an aircraft manufacturer of nearly 30 years standing and distinguished for technical competence in metal work, such as components for aircraft and hot parts for engines, show that the electronics division it recently established is on the road to accounting for 50% of the company's dollar volume of business. It was growth in this division that caused a sharp shift in Ryan's plans after it acquired a new production plant at Torrance because it was convenient to the Douglas Aircraft's DC-8 factory at Long Beach. Ryan found it had to have this production space for the electronics developments that were coming along so fast, and there were ways to keep the assembly of DC-8 engine pods in San Diego.

The *Atlas*, incorporating the second-stage *Centaur,* will become the "work horse of space" predicts Karel J. Bossart, "Father of the *Atlas*" and assistant to the vice-president of Convair for missiles and space exploration. "I do not see any competition for the *Atlas-Centaur* combination for getting a payload, not only to the moon, but beyond for many years to come," said Bossart.

Bossart does not believe the Russians have solved the weight problem for rockets as well as have Convair engineers. He points out that comparison of *Atlas* and *Sputnik* orbits show that the *Atlas* has less weight for its size. Bossart adds that Convair engineers knew the *Atlas* was capable of putting itself in orbit four years ago, but they had to wait until it had demonstrated its planned capability as a military missile.

One of the interesting innovations introduced in labor contracts on the West Coast last year was the "floating" holiday. It was devised, in the main, to round out four-day Christmas holiday periods. Last year the floater was December 26, the day after Christmas, and this year it will be December 24, the day before Christmas. But it won't work so well in 1960 when December 25 falls on Sunday, or in 1961 when it falls on Monday. Of course, new labor contracts are to be negotiated in the spring of 1960, but have no fears about retention of the "floating holiday."

Space problems, apparently, are reaching overwhelming proportions. Lockheed planned a dinner following the *Discoverer I* launching and found itself with a large and expensive prime ribs of beef on its hands when the shot was postponed. Rising magnificently to the occasion, Lockheed personnel found a buyer, but were not so lucky when the shot was scrubbed a week later. Until culinary and missile state-of-the-arts meet, it looks as though the answer to this technical problem will have to be cold cuts.

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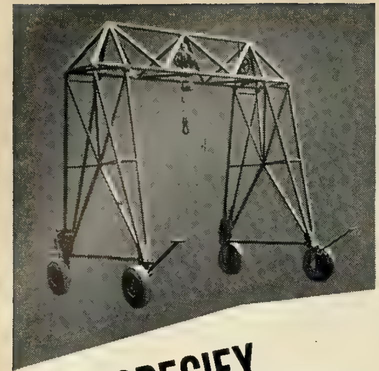

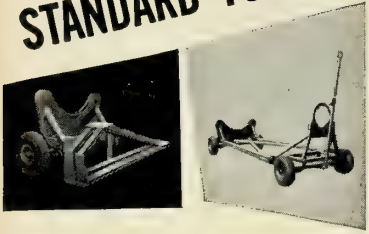

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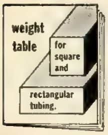

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propulsion engineering

by Alfred J. Zaehringer

Pre-packaged liquid propellant announced by the Navy at NOTS, though not named, may be based on mixtures of nitro hydrocarbons and nitric acid. China Lake openly reports burning rate studies on the following systems: (1) 2-nitropropane with 95-99% nitric acid; (2) 2-nitropropane and 97% nitric acid with and without powdered "Lucite" plastic; (3) butyric acid, nitrogen tetroxide and 99% nitric acid, and (4) isobutyric acid and 99% nitric acid. Propellants were among over 95 studied to investigate transition from smooth to turbulent combustion.

Ignition delay time of hypergolic rocket propellants can be reduced by the use of iron catalysts. Work was carried out by Stuttgart, Germany firm of Bolkow Development. Tests were carried out with nitric acid and various fuels such as amines and hydrocarbons.

Rocket chamber length ties in with chemical composition according to NASA. Using vaporization rate as a criteria, oxygen is found to have a shorter chamber requirement than for fluorine. This might mean that present oxygen engines would have to be radically modified in order to use fluorine. As far as fuels are concerned, hydrazine and ammonia seem to need longer lengths than the hydrocarbons. Work at the Russian Energy Institute is also aimed at correlating physical and chemical factors of fuels on combustion.

Liquid ozone has a detonation velocity of over 16,000 ft/sec. and a detonation pressure of nearly 600,000 psi at an initial temperature of –290°F. Temple University team has also reported values for gaseous ozone. Violent detonation characteristics of pure liquid ozone have held back U.S. rocket use.

Methyl nitrate is being looked at as a possible propellant ingredient by French researchers. Big problem has been the detonable nature of this powerful liquid. Water layer over the nitrate has been found to stop a detonation while heat alone (to 392°F) results only in slow decomposition.

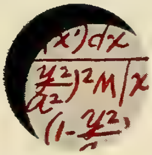
Slag problems resulting from combustion of boron and other metallic high energy fuels might be lessened if work at Haifa's Palestine Electric Corp. is any indication. Dolomite as a fuel oil additive increases the melting point of slag and ash and prevents adherence to combustion chamber walls. Sticky deposits of boron oxide have been a plague to turbojet, ramjet, and rocket people in propulsion development programs. Additives might be one way of lessening the problem.

Powdered solid fuel rocket motor has been successfully test fired by Pan-Tech Corp. of Ann Arbor, Mich. It looks good for multiple on-off, controllable auxiliary power units. Propellant flow is relatively insensitive to temperature.

Solid propellants for India? Ministry of Defense at New Delhi has been working on the burning of double base propellants at low pressures for some time. Strand burning techniques, as reported, are considered an important first step in the development of homogeneous propellants for artillery rockets and small missiles.

Fusion rocket chances look dim. One scientist sees a minimum reactor of 195 ft. diam and 390 ft. long due to quenching and loss at the walls. Another visualizes direct expansion. Both are plagued by "sun-like" working temperatures. "Cold" fusion systems are fairly unknown and appear to remain in the unknown of the distant future.

pinboard programming: easy as putting a round peg in a round hole



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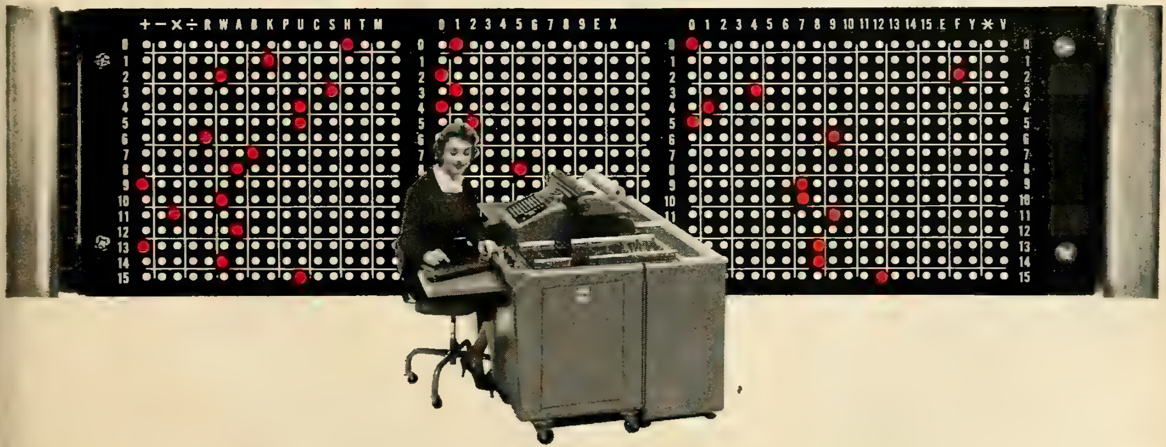
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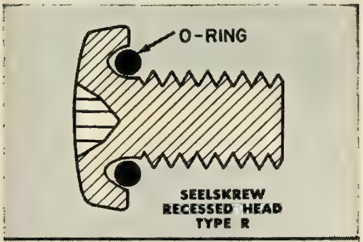

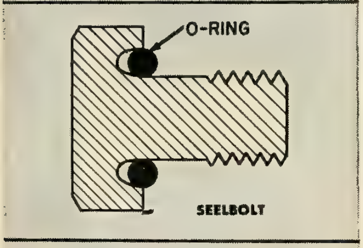

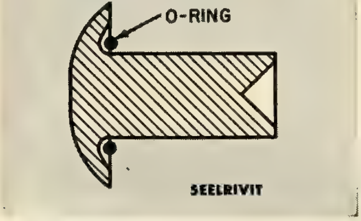

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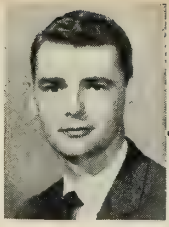


astrionics

by Raymond M. Nolan

People in industry who are subjecting transistors and other semiconductors to radiation have found that the results are not always displeasing. Most semiconductors suffer severe degradation under radiation. But if the dose is not lethal, they can recover and perform at something close to original specifications. One major manufacturer who has been testing sub-systems and systems in one of the AEC's facilities was pleasantly surprised when the equipment finally exhibited a memory and came back within specifications.

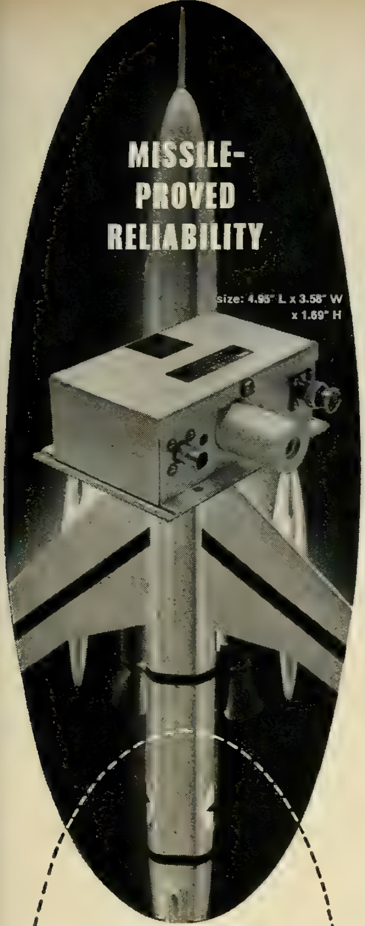
While many people believe that semiconductors will be the major source of trouble with nuclear warheads or engines, there are those who see other problems. Chief among these are components which depend on a petroleum or similar base for operation. Liquid-floated gyros, for example, normally are kept from final test to firing at an ambient of something like 180°F. Designers are concerned that prolonged (or even short-time) radiation will change the state of the flotation fluid, causing unwanted precession in the gyro due to viscosity or other changes in the fluid.

Another area might be oil-filled capacitors or transformers where the radiation could cause a change in characteristics. However, no report of any research or investigation in this field has been reported. At any rate, a healthy sign is that the problem of radiation is being considered in the areas where the most damage is expected. Engines, of course, are pretty much in the future, but the ambient radiation in nuclear warheads can be expected to cause trouble in the more immediate future.

The recent announcement of a "scientific breakthrough" by the White House when an atomic battery was exhibited was pooh-poohed by the more experienced people around Washington. Reason: Congressional testimony last January and February by USAF Col. Jack Armstrong with the Atomic Energy Commission revealed that the idea was picked up originally through a translation by Westinghouse of a Russian paper. Further information, however, indicates that the Russian approach was discarded and that the operating unit as it stands today is essentially an American unit. Maybe this means that "breakthrough" is the proper word.

Incidentally, along those same lines, m/r reported some months ago that Space Technology Laboratories went out to industry for bids on a similar device. Reports are that STL received a concrete bid from one battery manufacturer—specifications: one hundred pounds, three hundred watts, $10 million. The component would use Polonium 210 as the isotope source. Everything sounded fine to STL but the price, so it discarded the program. Even though the results would have been spectacular in any sort of an orbiting object, the specs people felt that the outlandish price did not justify the purchase.

Anyway, STL or some similar organization might be back at the old stand one of these days as we draw closer and closer to television and communications satellites. Here, long life of the power supply is of the essence. It might be possible to use solar cells, but the relatively large size would probably rule such items out in programs such as these. Maybe the only answer to problems of this type is the real "breakthrough" that we will experience when we discover how to use the limitless energy in space.



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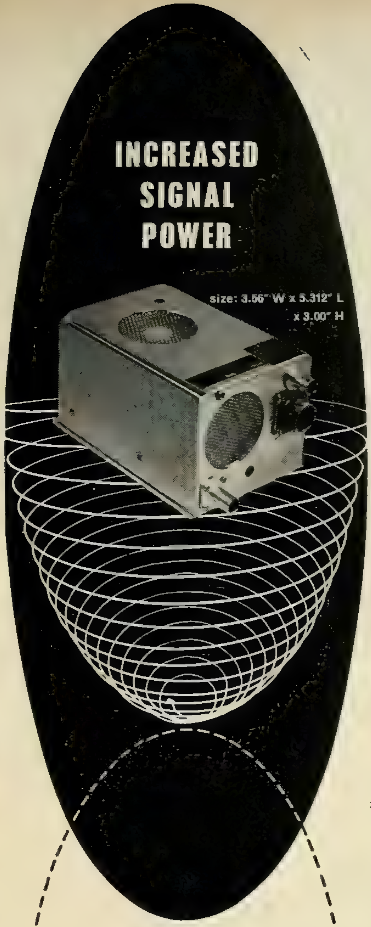

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missile people

The National Aeronautics and Space Administration has named chairmen for its 13 new research advisory committees which will give technical counsel on future research efforts and act as NASA's liaison with the scientific community.

The committees, which will have about 15 members each, and their chairmen are:

Fluid Mechanics; Prof. **William R. Sears,** Head of the Graduate School of Aeronautical Engineering, Cornell University. Aircraft Aerodynamics; **R. Richard Heppe,** Manager of Advanced Aerodynamics Research, California Div. of Lockheed Aircraft Corp. Missile and Spacecraft Aerodynamics; **Dr. H. Guyford Stever,** Associate Dean of Engineering, MIT. Control, Guidance, and Navigation; **Dr. Louis N. Ridenour,** Assistant General Manager of Research and Development, Missiles and Space Div., Lockheed Aircraft Corp.

Chemical Energy Processes; **James A. Reid,** Executive Vice President and General Manager of Astrodyne, Inc. Nuclear Energy Processes; **Dr. Walter H. Jordan,** Assistant Director of the Oak Ridge National Laboratory, Union Carbide Nuclear Co. Mechanical Power Plant Systems; **Gordon Banerian,** Manager of the Turbo-Machinery Div., Aerojet-General Corp. Electrical Power Plant Systems; **Dr. Krafft A. Ehricke,** Assistant to the Technical Director of Convair-Astronautics, Div. of General Dynamics Corp.

Structural Loads; **E. Z. Gray,** Systems Engineering Director of Boeing Airplane Co. Structural Design; **Professor E. E. Sechler,** Professor of Aeronautics, California Institute of Technology. Structural Dynamics; **Martin Goland,** Director of Southwest Research Institute. Materials; **R. H. Thielemann,** Senior Metallurgist, Stanford Research Institute. Aircraft Operating Problems; **William Littlewood,** Vice President of Equipment Research, American Airlines, Inc.

NASA will also be advised on human factors, medical, and allied problems of the manned space vehicle program by the Special Committee on Life Sciences, under the chairmanship of **Dr. W. Randolph Lovelace II,** Director of the Lovelace Foundation for Medical Education and Research.

Dr. Edward B. Doll has been elected a Vice President of Space Technology Laboratories, Inc. Dr. Doll, who played a key role in the recent Project *SCORE* which placed the "talking satellite" in orbit around the earth, will assume new responsibilities as Associate Director of STL's Systems Engineering Division. He will also continue to serve as program director for the USAF's *Atlas,* a position he has held since 1956. He joined Space Technology Laboratories in 1955.

Harley S. Jones, who served as Air Force aircraft and missile production planner through two wars, has been named Executive Vice President of Republic Aviation Corp. After retirement from the Air Force as a brigadier general, Jones received the Distinguished Service Medal for his formulation and implementation of production techniques. Following his retirement he rendered consulting services to Boeing on the *Bomarc* and to Republic on the F-105.

Bendix Radio's Division has expanded into the underwater communications and detection field and has appointed **Hans von Schultz,** ultrasonics expert, to the advanced development staff of the division's government products group.

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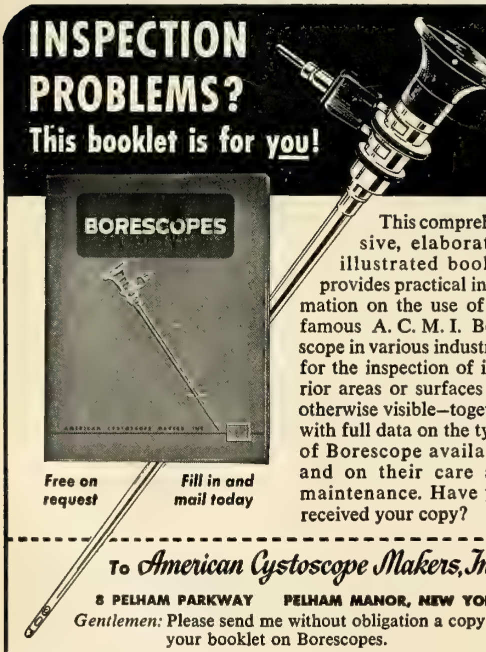

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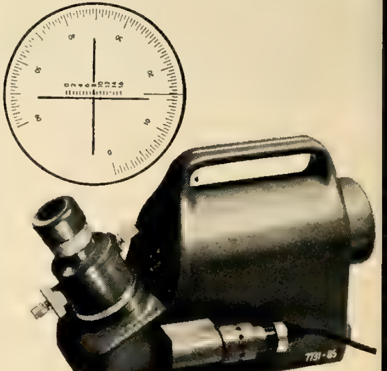

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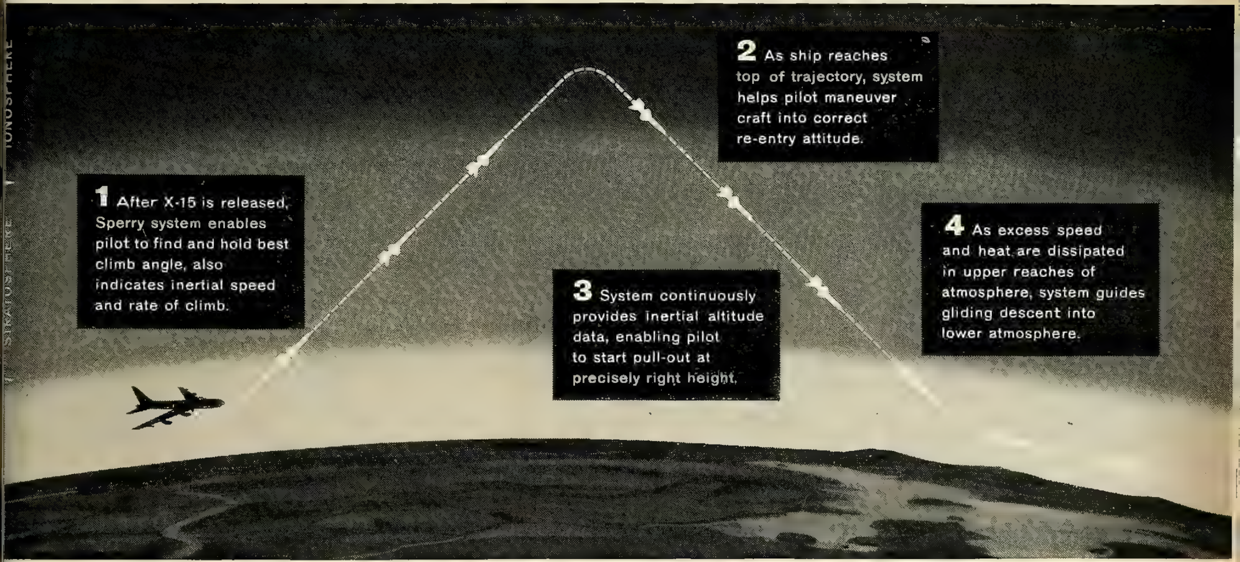

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when and where

FEBRUARY

IRE, AIEE 1959 Solid State Circuits Conference, University of Pennsylvania, Philadelphia, Feb. 12-13.

Conference for Manufacturing and Engineering Management, Computer and Data Processing in Industry, Purdue University, Lafayete, Ind., Feb. 12-13.

Heat Transfer Div. of American Society of Mechanical Engineers, Third Annual Symposium on Thermal Properties, Purdue University, Feb. 23-26.

1959 Engineering Exposition, Balboa Park, San Diego. For information, contact exposition office at 422 Land Title Bldg., San Diego, Feb. 26-March 1.

MARCH

IRE, AIEE and Association for Computing Machinery, 1959 Western Joint Computer Conference, Fairmont Hotel, San Francisco, March 3-5.

Institute of the Aeronautical Sciences, Flight Propulsion Meeting (classified), Hotel Carter, Cleveland, March 5-6.

Second Western Space Conference and Exhibits, Great Western Exhibit Center, Los Angeles, March 5-7.

Gas Turbine Division of the American Society of Mechanical Engineers, Turbine in Action, Cincinnati, March 8-11.

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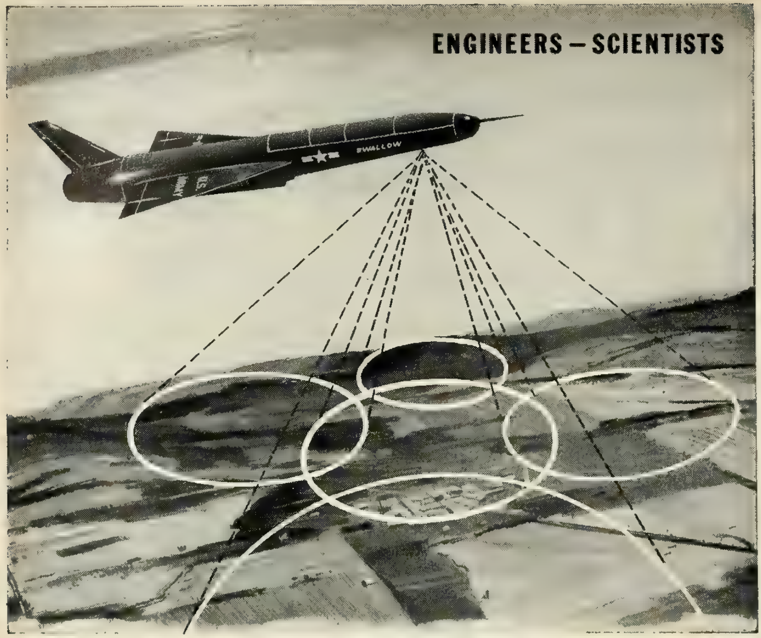

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Third Annual Shock Tube Symposium, Old Point Comfort, Ft. Monroe, Va. For details: Armed Forces Special Weapons Center, Kirtland AFB, Albuquerque, N.M. Attn.: SWRS R. R. Birnkoff. March 10-11.

American Society for Metals, 11th Western Exposition and Congress, Pan-Pacific Auditorium and Ambassador Hotel, Los Angeles, March 16-20.

The American Rocket Society, 1959 Sectional Meeting, Daytona Plaza Hotel, Daytona Beach, Fla., March 23-25.

Institute of Radio Engineers, National Convention, Coliseum and Waldorf-Astoria Hotel, New York, March 23-26.

Society of the Plastics Industry, 16th Annual Conference, Pacific Coast Section, Hotel del Coronado, San Diego, March 25-27.

Society of Automotive Engineers, National Aeronautic Meeting, Hotel Commodore, New York, March 31-Apr. 3.

APRIL

Conference on Electrically Exploded Wires, sponsored by the Thermal Radiation Laboratory of the Geophysics Research Directorate of the Air Force Cambridge Research Center, Somerset Hotel, Boston, Apr. 2-3.

1959 Nuclear Congress, Municipal Auditorium, Cleveland. For information: Engineers Joint Council, 29 West 39th St., New York. Apr. 5-10.

American Welding Society, 1959 Welding Show and 40th Annual Convention, International Amphitheatre and Hotel Sherman, Chicago, Apr. 7-10.

Air Force Association, World Congress of Flight, Las Vegas, Nev., Apr. 12-19.

American Society of Tool Engineers, Annual Meeting, Schroeder Hotel, Milwaukee, Apr. 18-22.

American Rocket Society, Man-in-Space Conference, Hotel Chamberlain, Hampton, Va., Apr. 20-22.

Institute of Radio Engineers, Spring Technical Conference on Electronic Data Processing, Cincinnati Section, Engineering Society Bldg., Cincinnati, Apr. 21-22.

Institute of Environmental Engineers, 1959 Annual Meeting, LaSalle Hotel, Chicago, Apr. 22-24.

American Rocket Society, Controllable Satellites Conference, Massachusetts Institute of Technology, Cambridge, Apr. 30-May 1.

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NEW PRODUCT BRIEFS

L RATE GYRO. One gyro that will e work of two units has been deed by Humphrey, Inc., the comsays. The new RG-18 series gyro its important reductions in the required for instrument and conpackages, according to Humphrey. motor is used to drive two separate s, making it possible to measure about two different axes. Another known as the RG-20 series is also ble to cover two rate ranges about ame axis. The new rate gyros are with two independent pickoffs, one ach axis or one for each range.
No. 238 on Subscriber Service Card.

O VALVE. The new FC-30 series ow control servo valves manued by the Cadillac Gage Co., Coast Div., retains all the features e Cadillac FC-2 series. But unit e has been reduced nearly 25% lves of equal capacity, and weight een reduced 20%. The standard valve weighs 14.5 ounces, and res 1.75x2.00x2.8 inches. Valves are ble from stock covering the entire range from .15 to 13 gallons per e. Cadillac says internal leakage 4 GPM valve at neutral position, MIL-0-5606 hydraulic fluid at 90°F 3000 psi supply pressure, is .09 maximum.
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MUTATOR SWITCH—A commutype of switch, Spec. 7122, for use talink receivers, telemetering syshigh-speed commutators, and apons where 100 shorting positions non-shorting positions are required extremely small physical space, has produced by the Daven Co. The has 100 positions in a panel space y 1¾" square. Depth is ⅞". It is le pole unit. The space-saving feaf this switch, which was developed cally for use in missiles, is due to olded wedge-shaped contacts set the epoxy with extremely closet spacing tolerances. These comor bars are solid silver alloy and otor is beryllium copper with a d silver edge making contact with ator. The ratio of on-time to offon the unit shown in the attached graph is 1:1. This can be varied hat for special applications.
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PROGRAMING CONNECTORS—For special computer applications, a complete line of miniature, quick-disconnect programing connectors are now available from Amphenol-Borg. All have an insert arrangements of 14 #16 contacts. There are a total of 60 plugs, pre-wired and coded for particular circuitry, and 3 standard receptacles. The various wiring arrangements in the plugs are indicated by code on colored tenite caps. Shell material is aluminum, dielectric is diallyl phthalate. The pressurized receptacles (30 pounds per square inch) incorporate a rubber "O" ring and seal, have aluminum shells and diallyl phthalate dielectrics. Withdrawal forces are 5 to 10 pounds, insertion is 15 pounds maximum. Connectors are recommended by manufacturer for programing various circuit arrangements in digital computers, data processing equipment, automatic test equipment and other forms of automation.
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VARIABLE SPEED DRIVE. A new lightweight miniature variable speed drive, small enough to fit in the palm of a hand, is being produced by Humphrey Products Div. of Humphrey, Inc. The company says the unit, designated the Servotran, offers frequency response equivalent to a hydraulic system and triple that of an electrical system in a mechanical drive weighing only 1¾ lbs. The drive without motor is only 3¾ in. long by 2 in. in diameter. A maximum of two inch ounces on the control shaft of the miniature Servotran changes speed from full forward to full reverse in .05 second. Output torque is constant and efficiency is between 85% and 95%.
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PANEL METER. A 3½-inch panel meter, embodying the different design concept introduced last year in the larger Model 561 meter, has been marketed by Assembly Products, Inc. The Model 361 meter occupies panel space of 3½ x 2 inches and projects 3/16-inch. Like the Model 561, it exposes only its indicating area, with the remainder of the meter fitting behind the panel. The dial and window are slanted and may be illuminated through a translucent rear window. Sensitivity ranges of Model 361 are 0-5 microamperes to 0-500 volts.
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MISSILES AND ROCKETS

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MISSILE LITERATURE

BROCHURE. An illustrated six-page brochure released by the DeJur Amsco Corp. gives specifications, outline dimensions and general information on right angle pin and socket connectors for printed circuit applications. These miniature right angle connectors are available in various contact sizes and molding compounds. Right angle pins dip solder to printed circuit board. Solder cups on receptable accept #20 AWG wire.

Circle No. 201 on Subscriber Service Card.

WIRE CATALOG. The 1959 catalog on Teflon insulated wires and cables is now available from the American Super-Temp Wire, Inc. This 64-page publication is completely new and contains 8 sections of the latest engineering information and prices on high-temperature magnet wire, lead wire, cables, tubing, and Teflon tape. Each section is preceded by detailed general information on the products cataloged. This information is consistent from section to section facilitating quick, easy reference on military specifications, temperature ranges, wire and cable constructions, colors, tests, etc. The catalog also contains technical bulletins and other information to provide engineers with design criteria for high temperature wiring.

Circle No. 202 on Subscriber Service Card.

AIR FILTERS. Construction and operating characteristics of the new model "B" roll-o-matic automatic renewable-media air filters are described in a bulletin recently released by American Air Filter Co. Inc. Featured is a description of what the manufacturer calls its 'miracle' media—a 65-lineal foot roll of impregnated, reinforced media composed of continuous, slightly curled, interlaced glass filaments held in place by a thermo-setting plastic bond to form a resilient pad or fluffy blanket having a nominal thickness of two inches. The new roll-o-mat media will not drip at temperatures up to 150 degrees and will not lose its adhesive qualities to dryness.

Circle No. 203 on Subscriber Service Card.

TOOL CATALOGUE. Announcement of a newly revised tool catalog, published in its ninth edition, has been made by Hi-Shear Rivet Tool Co. To keep pace with new varieties of hi-shear rivets, many new sets to drive stainless steel and harder material hi-shear collars have been added to the catalog. Very short rivet sets for use with stubby jiffy guns have become catalog items. New one piece driver blades to install hi-torque bolts in a full range of standard and miniature sizes are presently listed in the catalog.

Circle No. 204 on Subscriber Service Card.

FILTER CATALOG. A 16-page illustrated catalog describing the standard production mechanical filters manufactured by Collins Radio Co.

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PRESSURE TRANSDUCERS. Pressu transducers for aircraft and missil available from Minneapolis-Honeyw Regulator Co. are described in a ne 8-page pamphlet issued by the co pany's Aeronautical Division. The boo let outlines description, specificatio and modifications for each of sev basic pressure transducer devices. Ou puts can be derived from potentio eters, synchro transmitters or different transformers. Honeywell transducers a being used in thousands of aircraft a missile autopilots.

Circle No. 205 on Subscriber Service Ca

BULLETIN. Chemical & Power Produc Inc. has released a new technical b letin on their chempro line of fill teflon bearings—Technical Bulletin N CP-558. In addition to the seven sty of bearing materials listed in this b letin, other filler materials can be corporated for special applications. Th all have excellent wearing qualities a are less subject to thermal expansion a cold flow than pure teflon. Chemp filled teflon bearings are being us with excellent results by a great ma pump companies at speeds over 40 feet/minute. These filled materials a also suitable for electrical and electro applications, including molded and m chined spacers, inserts, connectors a other parts for use in high voltage, hi frequency and high temperature el tronic equipment, wires and cables.

Circle No. 207 on Subscriber Service Ca

MAGNETIC AMPLIFIERS. "What is magnetic amplifier?" is answered in latest issue of "Techni-Topics," publi tion of Magnetic Controls Co., ma facturer of magnetic amplifiers, te perature controls and related devic The six-page bulletin contains a br technical discussion of basic magne amplifier theory, circuitry and appli tions.

Circle No. 209 on Subscriber Service Ca

MISSILE PLUGS. The current state the art of missile umbilical plugs is scribed in a new 48-page catalog n available from Cannon Electric Co. describes and illustrates a represen tive cross-section of the latest devel ments in Cannon umbilical plugs signed for missile launching. These pl connect electrical circuits within missile to testing and control syste on the ground.

Circle No. 206 on Subscriber Service Ca

BUTTON CELL BATTERIES. A broch on button cell batteries has been p lished by Gulton Industries, Inc. 4-page, colored and illustrated pam let describes design and potentials a specifications of the VO-Series nic cadmium, button cell battery line wh includes types from 100 MAH to 1 MAH capacities in more than 50 tinct sizes and voltages.

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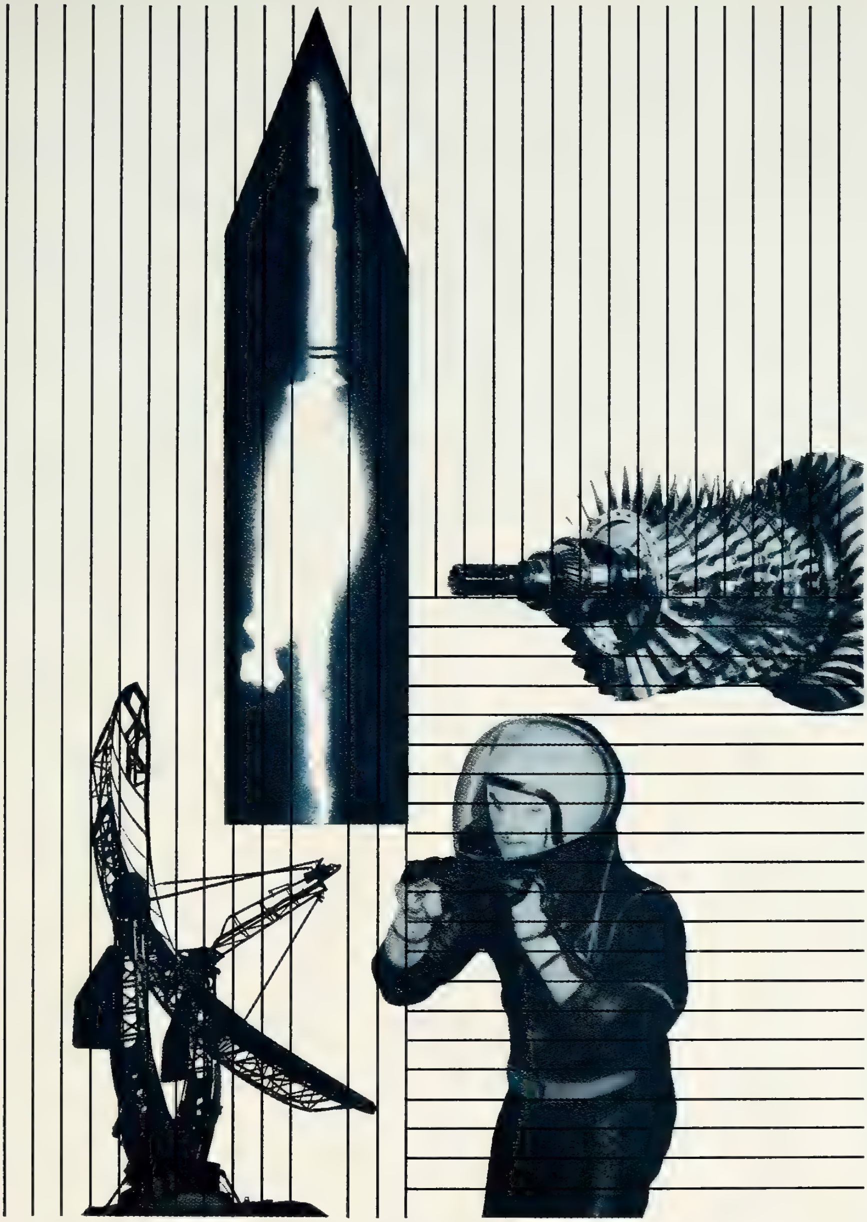

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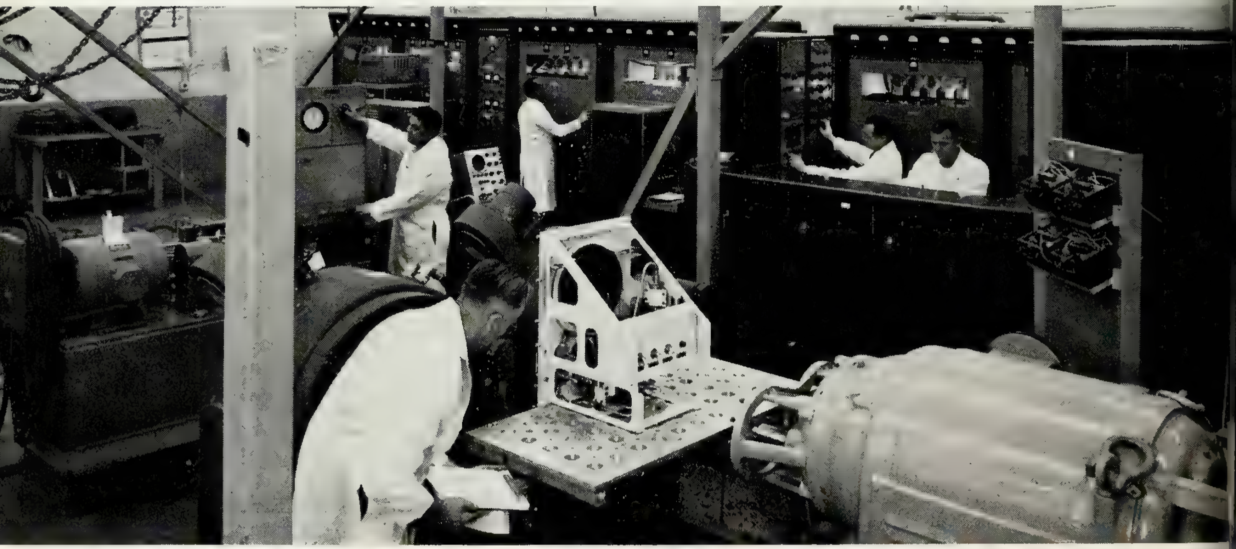

Typical installation of Ling Vibration Testing System installed i Missile Development Division of North American Aviation.

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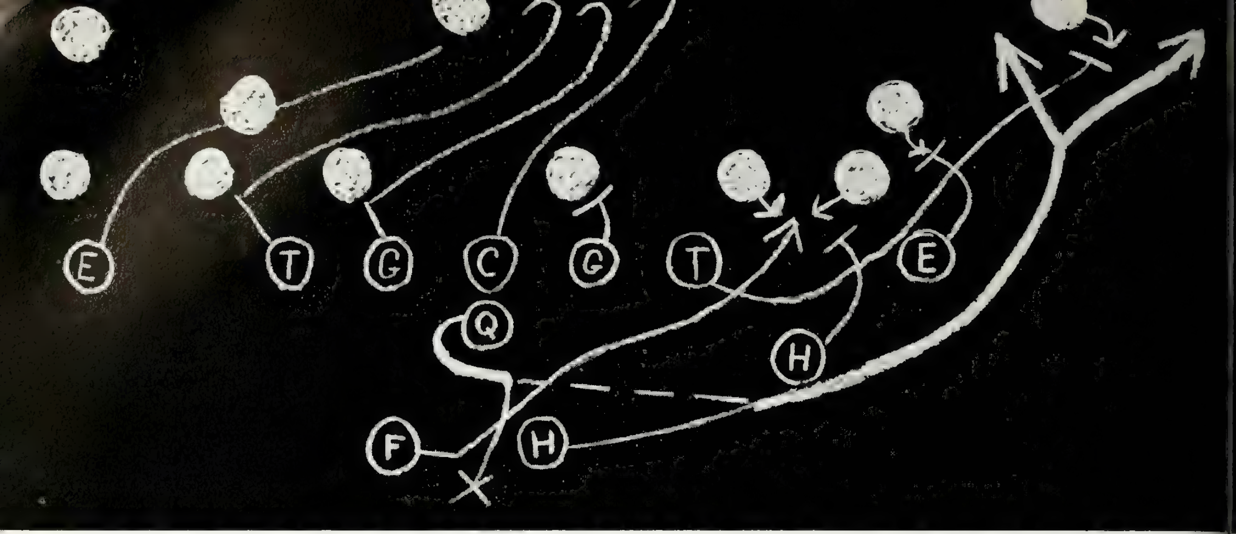
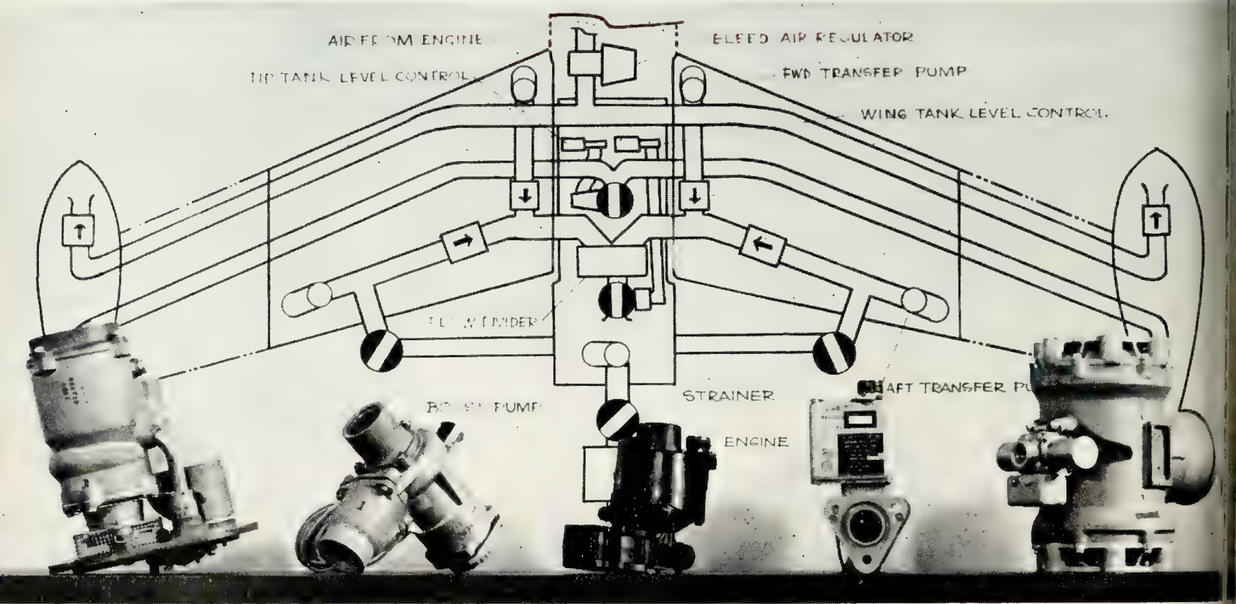


Team planning...



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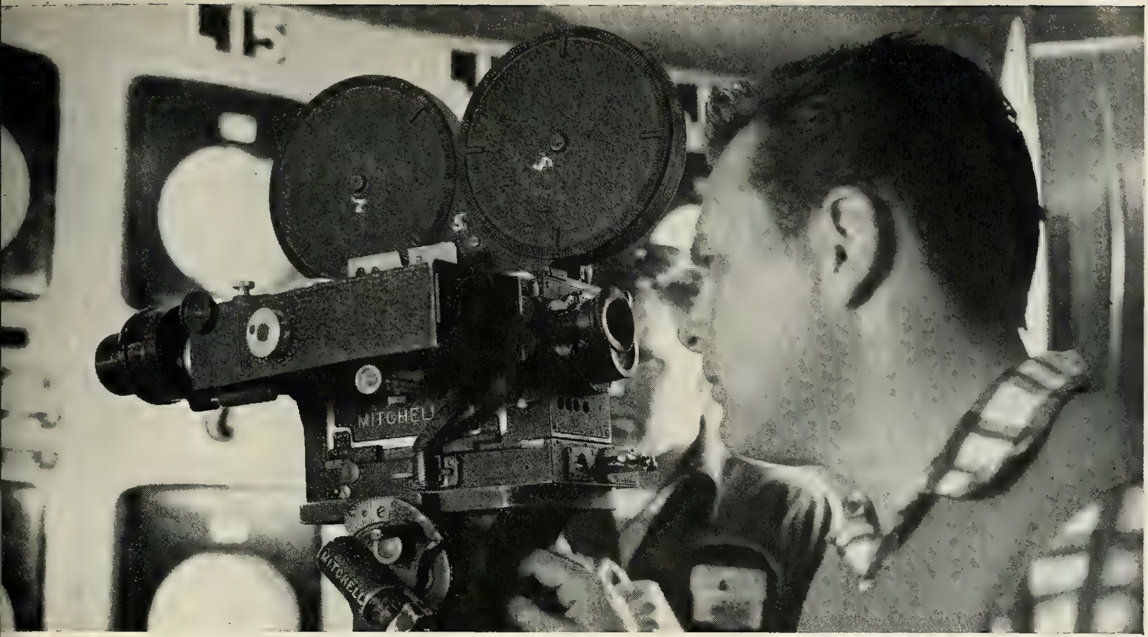

Critical moment in test of liquid propellant rocket engine is recorded by these fast moving instruments being filmed by Rocketdyne Film Unit. Rocketdyne is the largest manufacturer of liquid propellant rocket engines in the Free World.

OCKETDYNE FILMS ROCKET ENGINE TESTS VITH MITCHELL CAMERAS

dvanced Research Films Plus Top Industrial Features Filmed by 21-Man Unit

he Motion Picture Unit at Rocketdyne, a division of North American viation, Inc., employs both 16mm and 35mm Mitchell cameras to accuately record testing of power plants for the Air Force Thor IRBM and tlas ICBM missiles, and the Army's Redstone medium range and upiter IRBM weapons.

amera dependability is of critical concern where months of preparation o into each test, and retakes are impossible. Mitchell cameras assure niform excellence of highest film quality and trouble-free operation hat no other camera can match.

ther Rocketdyne films, like the full-length prize winning documentary Road to the Stars," demand extreme camera flexibility. Special Report lms, for example, involve interior shots of plant and production lines hich normally would require prohibitively expensive lighting. Mitchell ameras, with their 235 degree shutters, do this job easily with a miniium of lighting equipment.

o obtain information on the world's finest motion picture cameras rite today on your letterhead. Please specify your interest in literature n the Mitchell 16mm camera—or the 35mm camera.

Precision Test Firing of Rocket Engine at Rocketdyne's Propulsion Field Laboratory is recorded by Mitchell Camera in remote 1600 acre test area in Santa Susana Mountains, California.

Scene from "Road to the Stars," which won the top award in the Industrial Film Producers Association competition, shows camera unit in plant with Mitchell on track-mounted dolly. Producer-Director was Bill Adams.

Camera requires great flexibility from long range to close-ups like this which shows the Mitchell shooting a precise view of panel operations in the recording center during a test.

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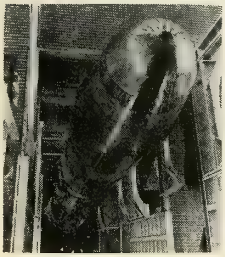
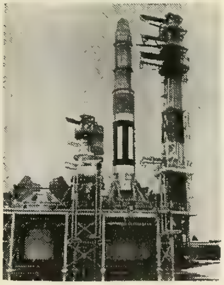
COVER: Guidance for *X-15* research vehicle will be tested in early phase of program. (p. 26)

LARGEST one piece infrared dome has been manufactured by Servo Corp. for Navy use. (p. 24)



MAMMOTH *Titan* is checked out in vertical test facility at Martin's Denver operation.



BATTING average for *Titan* has gone up with successful launch from Cape Canaveral.

OTHER side of the moon may look like this, according to a concept by Astronomer I. M. Levitt. (p. 14)

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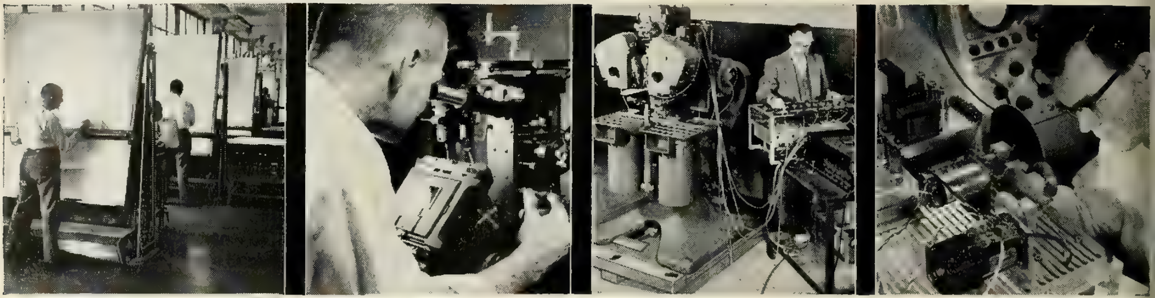

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Reliability Is Our Most Important Headache

The sound and the sight of successful missile firings from Cape Canaveral are no longer a novelty. The bird watchers still gather on the beaches and any big blast-off makes news, but even in the last few months it has come to be taken for granted that the older missiles—the *Jupiters, Thors, Atlases, Redstones* and other vehicles—can be scheduled with reasonable reliability. The first *Titan* got off with such a minimum of trouble it would have been considered miraculous two years ago.

Reliability from the launching pad is no longer the problem, but reliability at the point of impact is probably the greatest factor plaguing industry and the military today. It is the factor which has industry pleading for more missiles for more tests. It is a great factor in the reluctance of the Air Force to abandon the presently available manned aircraft. It is why Defense Secretary Neil McElroy promised the House Armed Services Committee that the missile program will be reviewed each month. It is why the Joint Chiefs of Staff are pushing so hard for *Polaris* and the ALBM—air-launched ballistic missile.

It is pointed up by the remarkably few nose cones which have been recovered. Getting the missile off the pad with a fine degree of certainty is one thing. Hitting the target with it is quite another.

Calculations for use of the intercontinental ballistic missile as a successful weapon call for its impact within a circle of five miles in diameter—with the target in the center. With this margin the warheads which the ICBM can carry will do a successful job of knocking out the target.

Our reliability tests, however, indicate that the reliability at point of impact is more nearly inaccurate by a factor of six. That is, the reliability of the ICBM is such that it can only be counted on to land in a circle of some 30 miles in diameter, with the target in the center.

This means that either more missiles must be fired or that the warheads must be increased in size and weight. The former is expensive and the latter simply brings up more problems. To increase the size of the warhead means increasing the propulsion and possible changes in guidance and these very factors might serve to increase the margins of error on impact.

Defense Secretary McElroy also told Congress "We are not putting our feet into concrete for three or four years ahead." Behind the remark was the reluctance of the Administration to commit itself to any program of missilery until the reliability problem has been solved. Behind it also was the hope which has been based upon the possibilities which the submarine-borne and air-borne ballistic missiles appear to offer.

The greater reliability here is based upon one simple factor—that because they are of much shorter range—1,500 miles for the sea-going *Polaris* and probably 1,000 for the missiles which the Air Force plans to launch from its bombers—they will have a built-in degree of greater accuracy.

There is no doubt that the ICBM programs based upon the *Atlas*, the just-fired *Titan* and the projected *Minuteman*, will and should continue. There is no doubt, either, that a great many missiles will have to be fired at the expense of a great deal of money before they reach a perfection of accuracy intended and planned for them. During World War II the Germans fired their *V-2s* at London from a distance of 200-odd miles and were content to hit within a 20-mile diameter circle 50% of the time. We want to fire 5,500 miles and hit within a five-mile circle. The margin of aiming error from the launching pad must be almost infinitesimal to achieve it.

Neither is there any doubt that we must continue to seek more accuracy in any form and any missile which can guarantee it. This is one of the reasons why the Administration is moving slowly and why reliability remains one of the most important headaches in the missile business today.

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Now, Fluoroflex®-T hose of Teflon® for 4000 psi service

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washington countdown

More business for *Corporal* . . .

was indicated by a recent "White Paper" released by the British Ministry of Defense, which stated that the British Army is now being equipped with the rocket. The paper also stated that the Royal Navy is preparing to build four guided missile cruisers and an American-engineered nuclear submarine.

One space agency . . .

sufficiently complete to include military programs was recommended by Rear Adm. John T. Hayward before Congress last week. The Assistant CNO for R&D told the House Space Committee that the Soviet challenge to our defense and in space must be met even if the budget is not balanced.

The list of questions . . .

for Secretary of Defense McElroy continues to grow as Congressional hearings move forward. Chairman Overton Brooks (D-La.) of the House Space and Astronautics committee said that the testimony before his committee up to last week did not support contentions of the Secretary. Brooks said he would welcome McElroy as a witness to the nation's knowledge, development and capabilities now and at the end of the year. McElroy is scheduled to appear before the committee on March 2.

600 space 'flights' . . .

have been made by test personnel in the Navy's centrifuge at Johnsville, Pa. The House space committee was told that about 15% of the "flights" would have been failures for one cause or another. Pilots have withstood 21 g's using a mercury couch and up to 25 g's for periods of 40 seconds.

TM-76A Mace will replace . . .

TM-61C Matadors now with the Air Force's 587th Tactical Missile Group at Sembach AFB, Germany. Deployment is scheduled for this spring.

The much-discussed *Polaris* range . . .

was nailed at 1200 miles by Director of Guided Missiles William M. Holaday. This is the early range objective of the accelerated program. A 1500-mile range will be attained on or before the date anticipated before the acceleration, Holaday predicted.

Basic research . . .

accounts for about 60% of the Navy's half-billion-dollar R&D budget, according to testimony before the House Space Committee. A large part of the money is in over 1500 contracts with non-profit organizations and universities.

Messerschmitt has named . . .

Robert Lusser as Director of Research and Engineering. Just prior to returning to Germany early last month to take over the post, Lusser was reliability coordinator for guided missiles at Redstone Arsenal. He came to this country in 1948 under a Navy contract and until 1953 worked at Point Mugu in missile reliability. At Messerschmitt before World War II, he designed the Messerschmitt 109. During the war he designed the world's first turbojet fighter for Heinkel, the 280. Lusser became an American citizen in 1956.

German marches . . .

were played by the *Atlas* talking satellite at one point during its month-long trip around the earth. Mortimer Rosenbaum, chief engineer of General Dynamics' Convair Astronautics Division, said a German radio station happened to transmit a tone that set the *Atlas* recording and transmitting the station's musical broadcast.

Plato "cancellation" reports . . .

are conflicting to say the least. DOD sources have said the transportable anti-missile defense system has been cancelled. But Sylvania Electric Products, Inc., prime contractor, said it has received "no official" word and is still working on the project which would have been used in conjunction with *Nike-Zeus*. The program started in September, 1953, under Sylvania and Cornell for feasibility R&D and development of some components.

Master plan . . .

for PMR will take 15 years and $4 billion worth of equipment, Congress was told last week. Plans call for 12 instrumented range ships to aid in recovery of test equipment.

Polaris doesn't interest British . . .

who apparently have rejected the missile in favor of their own *Blue Streak* as the nation's major retaliatory weapon.

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- **Galvanometer**
  natural frequency 55 cps
- **Hysteresis less than ± 0.1 div.**
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  changes due to temperature
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  over entire 50 div. chart width
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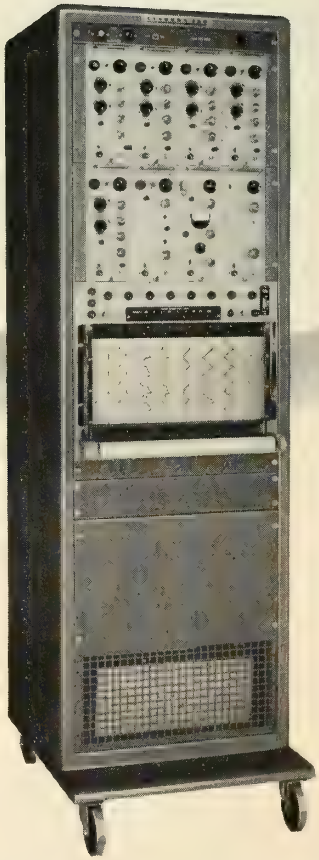

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industry countdown

Du Pont is boosting production . . . capacity for sodium and chlorine at its Memphis plant to meet the needs for the basic sodium metal in high-energy fuels and for chlorine in manufacture of titanium dioxide pigment, used in making chlorinated solvents. Completion of new facilities will up capacity for the two metals by about 50%.

Two new marketing units . . . Defense Industries Sales and Defense Industries Contract Administration—have been established by General Electric's Heavy Military Electronics Department to "enable the Department for the first time to make available directly to major defense prime contractors GE's technical know-how and facilities for designing and producing large, complex electronic subsystems." Systems would be comprised of ground-based radar suited to missile defense, ground control and guidance equipment for aircraft, missiles, spacecraft, etc.

Monsanto Chemical . . . will soon be producing its high-pressure polyethylene plastic at the rate of 100 million pounds a year. The speed-up is scheduled for completion in the third quarter of this year. High-pressure polyethylene production ultimately will reach one billion pounds a year.

Urgent need . . . for solving problems in development of the atomic submarine and its marriage to the ballistic missile is the object of a broad coordinated program now being planned by the Westinghouse Air Arm Division. All corporate facilities will be involved in the program with Air Arm acting as the lead division.

Progress of the *Nike-Zeus* . . . anti-missile missile program, still far from the complete hardware stage, apparently is worrying Pentagon planners who want a stop-gap system until the *Zeus* is ready. For this reason Boeing is expected to take part in AMM work in line with its *Bomarc* program. *Bomarc B* is well advanced and in production, and development of *Bomarc C,* with double the 400-mile range of the B, is underway. If and when Boeing enters the AMM field, its development is expected to be an evolutionary offspring of the *Bomarc* and a marriage of the *Bomarc* system and the *Minuteman* program.

***Hawk* is well on its way . . .** to becoming an operational weapon system with the latest contract award to Raytheon Manufacturing Co., amounting to $50,731,000, for production of the low-flying surface-to-air bird. Missiles and ground support equipment will be produced at Raytheon's Andover, Mass., plant. Ground support equipment will account for two-thirds of the missile system's dollar.

Vitro Labs will operate . . . and maintain the land and water ranges at the Air Proving Ground Center at Eglin AFB under a $1.8-million Air Force contract. The *Bomarc* IM-99A is now undergoing operational testing and crew check-out at the Eglin base.

***Polaris* is currently limited . . .** to the recently-announced 800-mile range by the state of the art of casing fabrication. First firing of the complete *Polaris* (1200-1500-mile version) is expected early this summer.

NASA will close . . . its liaison office at Wright-Patterson Air Force Base about April 1.

Contractor Relations . . . will be monitored by a new office set up at ARDC. The office will be under Col. Richard E. Sims, who has been named Assistant Deputy Commander for Technical and Contractor Services. New ARDC regional offices are being established in Boston, Washington, Denver and Dallas to supplement existing offices in New York, Chicago, and Los Angeles. Objective is to speed the evaluation and processing of R&D ideas.

Major Expansion . . . of Pennsalt Chemical Corp's four-month old plant at Portland, Ore., already is in the works. The new plant will expand ammonium perchlorate capacity by several thousand tons. Sodium chlorate facilities will have a 25% increase in capacity.

...speaking of

Missile Ground Support ***MOBILITY***

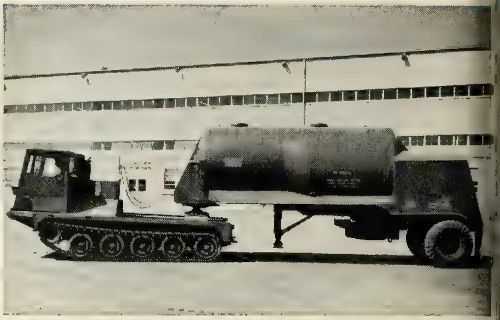
U.S. ARMY PHOTOS

WE MAY HAVE THE SOLUTION TO YOUR PROBLEM

When the Army Ballistic Missile Agency needed a small, lightweight prime mover sufficiently versatile to transport almost any size or kind of load, even over terrain inaccessible to other types of powered equipment, they came to FMC—and the ABMA Tractor was born.

This powerful multi-purpose tracked vehicle, conceived and produced by FMC for an Army development program, is another result of the more than 17 years experience acquired by FMC in designing and building more types of military-standardized tracked vehicles than any other company in America. FMC's accumulation of applied knowledge and experience in the field of mobility has led to the development and manufacture of missile ground support equipment—ranging from small tracked vehicles, transportable by helicopter, to complete missile launching systems.

From design concept through development, engineering and production – to delivery on schedule – FMC is qualified to help you solve your missile project problem. *Why not consult with FMC at the initial stage of project planning?* Contact us today for more information.



As a multi-service prime mover, the FMC-built ABMA Tractor is powered for moving heaviest loads on short or long hauls with ease and dispatch. This sure-footed, tracked vehicle handles all types of trailers, is equally capable on soft, rough or surfaced ground.

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Ordnance Division

Missile Equipment Section I-J

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BRUARY 16, 1959—VOL. 5, NO. 7

missiles and rockets

MAGAZINE OF WORLD ASTRONAUTICS

Vhat Will Be Outcome of Probe of STL?

Congress may recommend that STL sever all financial ties to Thompson Ramo-Wooldridge, and that a limit be placed on profits and salaries of company officials

WASHINGTON—Although the cur- nt Congressional scrutiny of the Air orce's ballistic missile program and management by Space Technology iboratories is not expected to change e concept or its operation, look for ese Congressional recommendations:

1. That STL divest itself completely any financial ties to Thompson amo-Wooldridge Corp.

2. That a limit be placed on profits d salaries of captive company offi- ıls.

• **Air Force-TRW defense**—The ilitary Subcommittee of the House overnment Operations Committee ard AF officials strongly defend their anagement concept, claiming it was sponsible for their ballistic missile ccesses, that "we're well ahead of hedule" and that had the regular line command prevailed, time lost would ve been "not a matter of months but matter of years."

Both AF and TRW officials pointed t that the corporation is now severely ndicapped when it comes to getting r Force business.

The Air Force has issued a direc- e that bars TRW from contracting th them on the ballistic missile pro- am, except where it is the sole source otherwise uniquely qualified. In view the furor it would cause, Air Force ntractors are hardly likely to over- le the directive unless absolutely cessary.

STL officials told the committee at although their stock is owned by RW, from which it split off, its man- ement is entirely separate. The com- ny indicated it would break its finan- l tie to TRW "if such a step is later und to be desirable and proper."

• **More questions**—Other subcom- ittee questions and STL answers:

Q. What advantages did the com- ny gain from its five-year "privi- ged" position as management team r the ICBM program?

A. STL does get proprietary information from contractors, but it hands out more such data to contractors than it takes in by virtue of the fact that "it is the technical leader in the field." It makes less money than "the average contractor who builds the hardware."

Q. How much has the Ramo-Wooldridge Corp. (of which STL was formerly a division) earned since it first entered into the contract with the Air Force in October, 1953?

A. Total retained earnings for the five years were about $4 million; its reimbursements paid by the Air Force totaled 2.8% of the overall cost of the AF ballistic missile program or something under $100 million; the systems engineering approach saved the government $200 million over the conventional method of contracting.

Q. Does STL recommend or decide which companies should be given contracts?

A. This is held in the Air Force. STL directs the program, gives technical advice, writes specifications. The Air Force then goes to the best source.

The hearings brought out that the system engineering approach grew out of a study made in January, 1954, by an Air Force committee of which Dr. Simon Ramo and Dr. Dean Wooldridge were members. They resigned shortly afterward but as early as October, 1953, they had an Air Force study contract. In July, 1954, the Scientific Advisory Committee recommended that the team of Ramo and Wooldridge be given the job of technical direction and systems engineering of the ballistic missile program. Under terms of the agreement, they were barred from any physical development that might lead to production contracts.

After three days of testifying, the STL witnesses—including President Louis G. Dunn and Board Chairman Jimmy Doolittle—went to their hotel to pack for the trip back to the coast and to celebrate the first successful *Titan* flight, announced that afternoon.

Scout Could Orbit 150 lbs.

WASHINGTON—The National Aeronautics and Space Administration is developing a "poor man's rocket" with an estimated weight of 3500 pounds capable of orbiting 150 pounds at a nominal 300-mile altitude.

Called Project *Scout*, the vehicle will be a four-stage rocket using modified *Sergeant* engines and newer solid motors of advanced design and high performance.

The first stage will be a modification of the test *Sergeant* (XM-33) developed by Thiokol for the earlier *Polaris* vehicles.

The other stages will be modified *Sergeants* and newer solid engines under development by the Allegheny Missile Laboratories. Contracts have been let to Thiokol and Allegheny for procurement of motors for all stages.

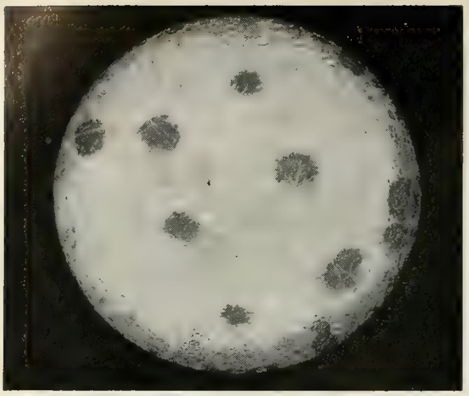
NASA is currently negotiating with North American Aviation, Inc., on the structure contract.

Basic development of the rocket is being carried on for NASA by the Langley Aeronautical Laboratory.

The *Scout* should provide for NASA and the military services a cheap, reliable, efficient rocket for high-altitude research, re-entry tests, and for testing components before miniaturization.

The weight of the *Scout* indicates the number of pounds of vehicle needed to put one pound into orbit will be drastically reduced. According to Dr. Homer Joe Stewart, director of NASA's Office of Program Planning and Evaluation, today's best ratio is 1000 pounds of vehicle for every pound orbited. The *Scout* will apparently reduce this ratio to anywhere from 25 to 40 to one.

Dr. Stewart also said that the new rockets developed specifically for space exploration could reduce cost down from the $10,000-per-orbiting-pound expended by the military rockets to about $300-per-orbiting-pound.

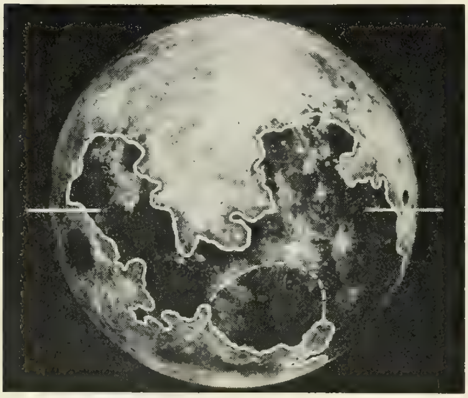


WILL PHOTOGRAPH of the far side of the moon be similar to this concept by the author? First successful lunar probe television camera could transmit such a photograph back to earth.

What Is Topography of Moon's Other Side?

That terrain may be rougher with more craters and smaller mares, astronomer believes

by Dr. I. M. Levitt
Director, Fels Planetarium of the Franklin Institute



HEAT FROM a small planetismal impacting near Mare Imbrium (dotted line) created a lava flow that probably formed other seas on the earth side of the moon (solid line). Moon is inverted with the south pole at the top.

PHILADELPHIA—At the dawn of time when the moon was still hot, plastic and near the earth, giant tides were generated on its crust. Eons later, when the moon had solidified, the 3600-foot tide was locked into the solid structure of the moon. The earth's gravitational field then captured the long axis of the moon, keeping it always pointed toward the earth.

The events of that time are apparent today: The same side of the moon always faces the earth and the other side is largely a secret.

It is not entirely accurate to say that we have never seen the other side of the moon. We actually do catch glimpses of part of the other side. This "libration" is created as the moon turns on its axis uniformly while circling the earth in an ellipse.

Since the motion of a body in an ellipse is not uniform, the moon as seen from the earth speeds up or slows in its rotation, permitting us to see slightly more than half of its surface.

Actually 41% of the moon is always seen, 41% is never seen and the other 18% can be seen at one time or another.

• **Secrecy nears end**—The moon will not keep its secret for very long because man will soon—perhaps within the next decade—photograph its far side. In the meantime, if plans of the new National Aeronautics and Space Administration are consummated, a lunar probe to circle the moon and relay back information may be realized in the next few months.

Hence, we may have answers in the immediate future to these age-old questions: What does the other side of the moon look like? Is it the same as our side or is it radically different?

Scientists have long speculated, but nothing definitive has ever been presented. The question naturally arises: Is there any way in which we ma postulate a surface "picture" of the fa side?

Despite the fact that astronomer have considered the moon a lifeles body without water and atmospher many believe that man can build u a civilization and live "off" the moon In the course of an intensive study some intriguing facts about the moo were unveiled and from these it i possible to arrive at a statistical picture of the moon's other side.

What is on the other side is related to the surface conditions of th side facing the earth. For that reaso it is well to spend some time discussing the features which can be seen

• **Visible clues**—A picture of th full moon shows that fully half th surface is made up of flat areas whic early astronomers called "maria" o seas. The other half of the visible sid is composed of pitted areas or crater ith an incredibly rough topography.

The aspect of the other side is ighly dependent on how the seas ame into being. The answer to this ay not be realized until man puts ot on the moon. But it is possible ow to draw some conclusions.

The consensus is that several bil-on years ago a giant meteor, or lanetesimal, hit the moon at the place oday called Mare Imbrium. The lanetesimal was supposedly from 125 200 miles in diameter and struck ie moon with a nominal speed, which r. Harold Urey puts at about 1.5 iles a second. If the speed were reater the resulting explosion would ave given the region a symmetrical attern which is not apparent.

• **Mighty blow**—There was a tre-iendous amount of Kinetic energy in-erent in the moving planetesimal due its motion. If the planetesimal was 25 miles in diameter with a density of 5 and a speed of 1.5 miles a second, ien the energy released on impact ould have been 4.15 x 10^{32} ergs. Dr. eorge Gamow has indicated that an g is the energy of a small mosquito ying across a room. Yet, the energy f impact suggested above is equal to 50 billion atomic bombs.

To represent this in another way, ie entire earth might be divided into ty blocks. Then, says Dr. Urey, if ie atomic bomb were exploded on very city block we would have ex-ended the same amount of energy as as given up when the planetesimal ruck the moon.

• **Seas formed**—Precisely what hap-ened at the time of impact no one iows. But this much is known: There as a tremendous amount of energy vailable as the kinetic energy of mo-on. This was converted to heat and ie result was the formation of a emendous pool of lava which flowed om the Mare Imbrium region to rm, to the east, the Mare Nubium id the Oceanus Procellarium.

The lava flowed to the west to form ie Mare Serenitatis, Mare Tranquil-tatis, the Mare Foecunditatis and the iver we call Mare Nectaris. If other as existed prior to this event, and iere is some evidence to indicate this, iey were submerged in the flood of va which flowed from the impact oint.

Prior meteoritic impacts could have rown up mountain ranges and the va flows would have inundated iese as well as some of the larger raters bordering this region. The ooding of the Mare Imbrium floor indicated by isolated peaks still ound in that region.

Violent explosions ripped along the irface through mountains to create the valleys and rifts which can all be traced back to the impact point in the Mare Imbrium. Away from the seas around the south pole, we find the old moon whose craters antedate the Mare Imbrium catastrophe.

• **Some conclusions**—If what has been said makes sense, we can say that nowhere else on this side of the moon was there an impact by a planetesimal of the size that struck the Mare Imbrium region. Certainly if there was we would see it and no comparable area is visible.

There are several other small seas on the moon which we see when the moon librates. But in every case, except one, we see the entire small sea. Thus it becomes apparent that the only region where another planetesimal could have hit the other side to create a large sea area similar to the Mare Imbrium is directly in the center of the other side. Unless it hit dead center we would see the edges of the seas coming around the limb.

Now we begin to use probabilities. The odds of a planetesimal hitting directly in the center of the other side are so small as not to merit serious consideration.

Thus we come to the conclusion that the other side of the moon is wholly unlike the side facing the earth.

• **A likely picture**—It appears possible to obtain a statistical picture of the other side of the moon.

A careful look at the near side shows that the southern half is composed principally of the old pre-mare areas, unaffected by the encroachment of lava flows from the impact center. Thus we should expect to see the other side as made up of material which comprises the southern half of the visible moon. But what sort of craters, how many, and what kind of seas should we find?

To arrive at this picture, the moon is divided into its northern and southern regions. Then the areas of the moon which were obviously the result of the lava flows are traced. This ratio of the old moon to the total southern half which may be called the "deficiency factor" turns out to be 79.6 per cent.

Then the craters are counted on the whole moon which have diameters from 20 to 29 miles, from 30 to 39 miles, from 40 to 49 miles, from 50 to 59 miles, from 60 to 79 miles, from 80 to 99 miles and finally from 100 to 146 miles. The same range of crater sizes were counted in the southern half. The ratio of the two gave a number which may be called the "rectification factor." This factor is used to eliminate the effect of the seas in the northern hemisphere.

By taking the number of craters of a given size in the southern half and multiplying by two we have the number for the entire side of the moon. This number multiplied by the deficiency and rectification factors yielded the number of craters on the other side of the moon of a given diameter.

The total number of craters 20 miles or over in diameter on the side of the moon facing us is 227. However, the total for the other side is 395 craters or more. Thus the absence of the large sea areas on the other side of the moon almost doubles the number of craters.

• **Smaller seas**—Examination of the near side and the limb due to libration discloses many of the smaller seas like the Mare Crisium, Mare Marginus, the Mare Symthii, Mare Humboltianum, etc. From the presence of these we may draw the conclusion that there should be at least four or perhaps five small maria on the other side of the moon which we cannot see.

Thus from a purely statistical study it is possible to derive the total number of craters and the maria that should be present on the other side of the moon. Whether the numbers are precise we do not know, we can only indicate the order of magnitude of this array.

The positions of the craters and maria we cannot know. This is a mystery which will be resolved only when we get around to the other side of the moon.

Perhaps in 1959 a lunar probe will leave the earth to circle the moon and televise back a picture of the other side. If such a picture looks like the one accompanying this article, no one will be more surprised than the author.

5½ Million Units

Transistor Sales Reach Another Record

WASHINGTON—Sales of transistors in December increased substantially over November to establish an all-time-high for any given month in the history of the industry, the Electronic Industries Association has announced. Unit sales of transistors during 1958 increased by 64% over 1957.

Factory sales of transistors in December totaled 5,627,700, valued at $16,595,616, compared with 5,440,891 units valued at $12,441,759 in November, and 2,773,000 units valued at $6,619,000 sold in December, 1957.

Cumulative sales of transistors during 1958 totaled 47,050,814, valued at $112,729,427, compared with 28,738,000, valued at $69,739,000, during calendar year 1957.

ASTRONAUTICS in the news . . .

Thor IRBM Production

by Fred S. Hunter

Los Angeles—Final assembly of the 65-ft. *Thor* missile is underway on four parallel lines at Douglas Aircraft's Santa Monica missile plant. No production figures have been released, but the company has disclosed that all requirements have been filled and an accumulation of missiles are in reserve for emergencies.

To date 32 *Thors* have been fired in the flight program of the Douglas IRBM. Of these, 16 have been described as completely successful, 12 as partially successful (meaning important data has been obtained) and only four were categorized as failures.

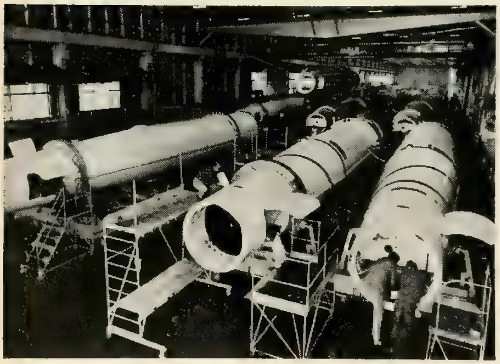
Design of the *Thor* is now frozen, but Douglas and its associated contractors will continue to seek improvements in the system, President Donald W. Douglas, Jr., reported.

Douglas noted that, although many changes have been made in small items in development of the *Thor,* no structural modifications have been required. "There has never been a major fix on the *Thor,*" he said.

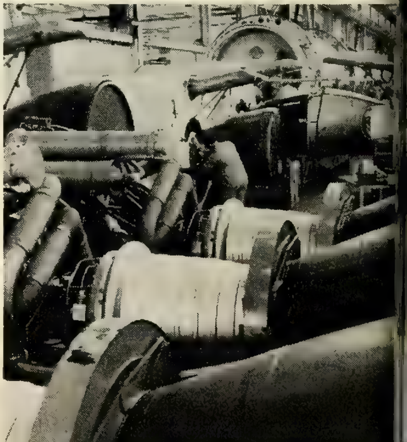
Born of the urgent military need for a ballistic missile which might be set up in NATO countries, notably Britain, the *Thor* program was set in motion at the Douglas company on Dec. 27, 1955. Within one month the size of the missile was determined; within seven months engineering drawings had been released, and within 13 months the first test firing took place.

This was unsuccessful, but defects were subsequently ironed out and by December, 1958—within two years after the project's start—a *Thor* with guidance system flew its prescribed course over the Atlantic test range with impact very close to target. From the first missile, Douglas has used production tooling in turning out the *Thor* at Santa Monica.

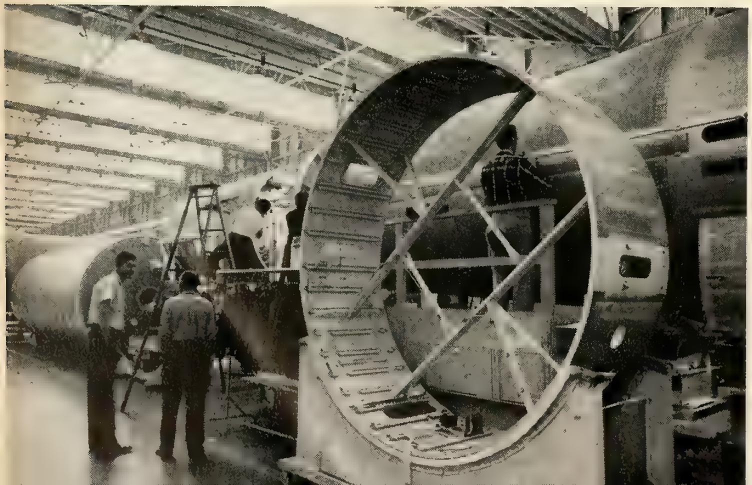
No new information on costs of the *Thor* project has been released. The missile itself has been disclosed as costing between $650,000 and $700,000, without R&D.



THREE *Thors,* minus warheads and nose cones, have guidance systems installed on the final assembly line at the Douglas Santa Monica plant.



ENGINE sections, tanks, and guidance and control sections are joined and all cables and lines attached to *Thor.*



THE 150-165,000-lb. thrust engine system for *Thor* is joined to the engine body section. Missile is reported to cost between $650-700,000 dollars.

Jupiter IRBM Production

by Alfred J. Zaehringer

DETROIT—With its *Redstone* misile nearing end of production and ith a limited outlook for producing *upiter* IRBM's, Chrysler Corp.'s Misle Division has formed a special roup aimed at keeping the firm in e missile business. The new group known as the Advanced Projects rganization.

APO, m/r has learned, was formed bid on the *Minuteman* ICBM sysem. After plunking several thousand an hours and several hundred thouand dollars into the Air Force proosal, Chrysler decided to keep APO oing to look for new business.

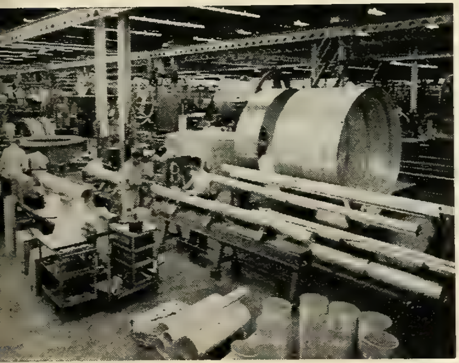
Biggest hope at Chrysler and ABMA is use of existing vehicles as research and development tools in up-and-coming programs. It was learned that the advanced projects group is actively working on proposals for use of *Redstone* missiles in high-altitude research, satellite vehicles, and nuclear weapons testing at extreme altitudes.

If warhead tests prove successful—and if *Nike-Zeus* can be brought to test soon, Chrysler's APO hopes that either *Redstone*, or more probably *Jupiter*, will be used as a target missile for the anti-missile missile.

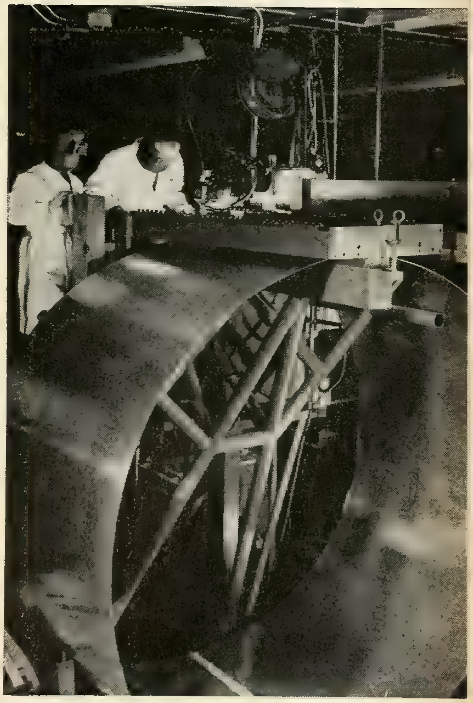
Usually reliable industry and Army sources have told m/r that ABMA will try to keep *Jupiter* going through use of missiles as supply and troop carriers.

For the immediate future, however, APO is trying to up-grade present missiles. Some proposals include: substituting nitrogen tetroxide for LOX to produce storable, ready-to-fire missiles; switching RP for alcohol, and using the hydrazines for better performance.

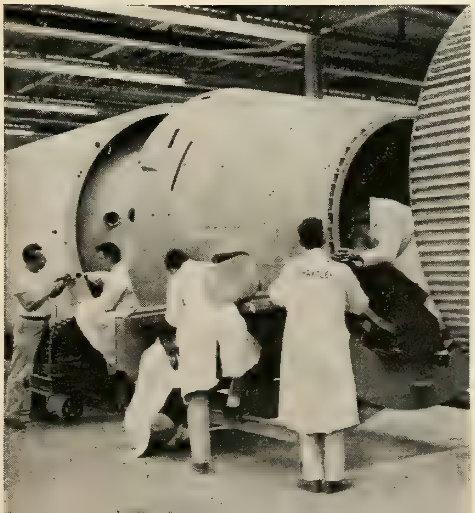
In addition, a strong segment of APO is keeping a firm eye on all solid propellant developments just to be on the safe side of any possible weapons systems trends. Along these lines, one big hope for Chrysler may be selection as systems manager for the *Nike-Zeus*. And use of *Jupiter* or *Redstone* as target missiles could also be a healthy stimulant.



TANK sections, with circumferential stiffeners attached, forming and assembling jigs, and propellant flow lines are shown being assembled on the *Jupiter*.



BODY SKIN for *Jupiter* is rolled and joined by automatic welding equipment in the fabricating tank section of the Chrysler Corp.'s Missile Division.



UIDANCE and control ection of *Jupiter* is ined to the forward tank ection. Aft section can e seen at the right.

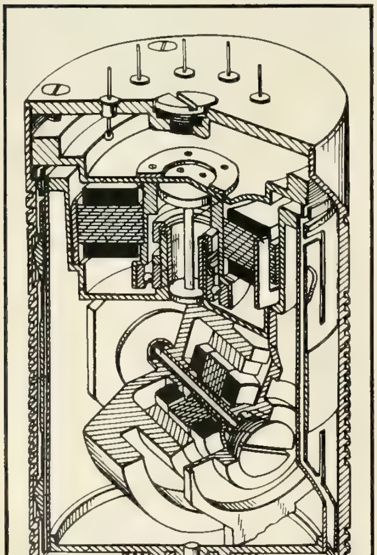
New Approach for Liquid-Floated Gyros

Norden Division of United Aircraft gets patent for unheated gyro that mechanically compensates for temperature variations

WASHINGTON—The persistent problem of temperature that has dogged designers of liquid-floated gyros since their inception seems to be on the way to solution.

In a patent (No. 2,865,206) granted Dec. 23, Thomas Quermann of the Ketay Department, Norden Division of United Aircraft, describes a new unheated, floated rate gyro in which temperature compensation is achieved by mechanical means.

•**Present drawbacks**—Liquid gyros presently in use operate well but have the disadvantage of the flotation fluid changing viscosity and density with changes in temperature. This means that unwanted torques and, consequently, precessions are set up within the gyro unless the fluid is kept at an even, high temperature.



CUTAWAY DRAWING is representative of gyros being produced at Norden.

Because of this, liquid-floated gyros are usually kept at operating temperature from the time they are manufactured until they are used. Present guidance systems using liquid-buoyed gyros are the *Atlas, Titan, Thor, Mace* (in its inertial version), *Sergeant,* and presumably, the *Polaris.*

The only serious competitor to the liquid units for high-accuracy guidance systems has been the air-bearing gyro manufactured by Ford Instrument Company for the *Jupiter* and the *Redstone* and by the Eclipse-Pioneer division of Bendix for the *Pershing.* But here, while temperature is not a serious problem, a supply of clean dry air is a necessity.

This brings in the requirement of more weight for carrying and processing the air. The liquid-floated gyros in use stem from early inventions of Dr. C. S. Draper of MIT and the air-bearing gyros come from Dr. Wernher von Braun's group at ABMA.

• **Constant damping**—The new component, called the buoyed rate gyroscope in the patent application, proposes to solve the foregoing problems by adding mechanical elements to achieve temperature compensation. This keeps the damping force exerted on the gimbal housing substantially constant. Most liquid gyros maintain a uniform damping force by means such as a volumetric thermostat which controls a heater in response to changes in volume of the liquid temperature and hence the liquid viscosity.

The patent points out that while an electrical system maintains the temperature constant, it operates only to heat the liquid and includes no means for cooling it. This requires that the liquid be maintained at a temperature higher than the maximum to which the assembly will be subjected. A mechanical compensator eliminates this high-temperature requirement.

Reports are that most liquid-floate gyros now in use operate somewher in the vicinity of 180°F. Querman estimates that most of these gyros nee between 50 and 100 watts to maintai this temperature.

• **Shifting cage**—The gyro has motor supported in a sealed housing buoyed by a liquid contained in a outer housing while being constraine to rotate about an axis at right angle to the gyro spin axis. An axially-shiftable, cylindrical cage between the housing and the casing, restrained agains rotation relative to the casing, holds film of liquid which provides a damping force for the housing. The cag has a wall formed by a number of resiliently-supported sections adapted t be actuated effectively to decrease th cage diameter.

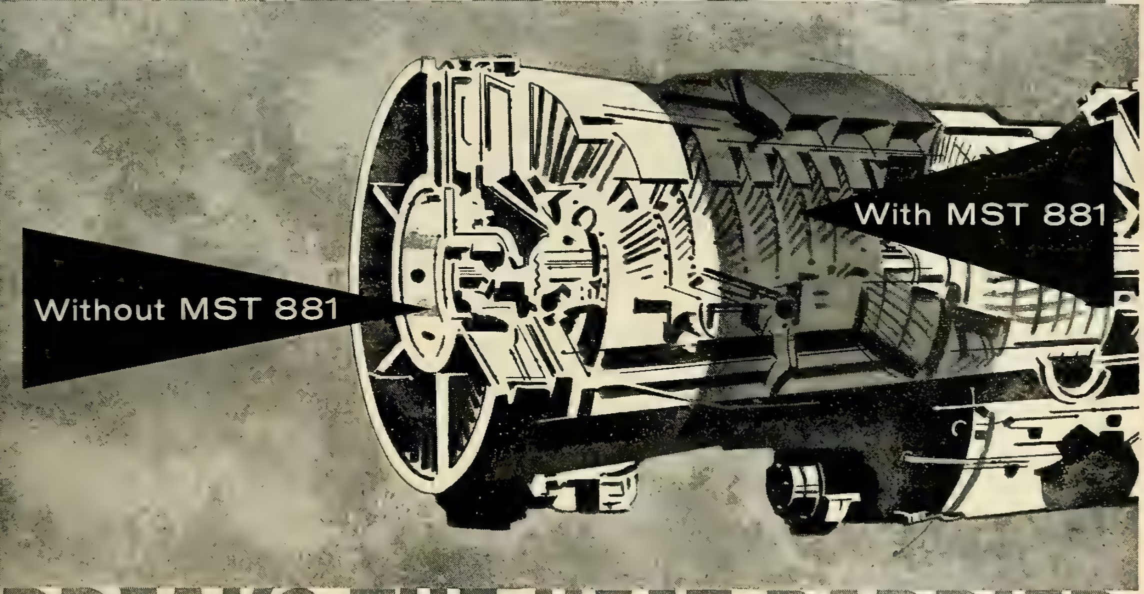
A bellows which responds t changes in liquid volume shifts the cag longitudinally in reference to the oute casing. Interengagable means carrie by the casing and the cage walls mo the walls inward or outward from th housing to increase or decrease th thickness of the liquid film providin the damping force. The decrease liquid viscosity resulting from chang in temperature therefore is compensate for to maintain a substantially consta liquid damping force.

• **In production**—The accompan ing cutaway drawing is not intended show the exact gyro being produced Norden. It is only representative of family of such units that have been production for more than a year. Of t group in production, some units opera on 115 volts and others use 26 vol Either inductive or potentiometer pic offs are supplied with various values excitation.

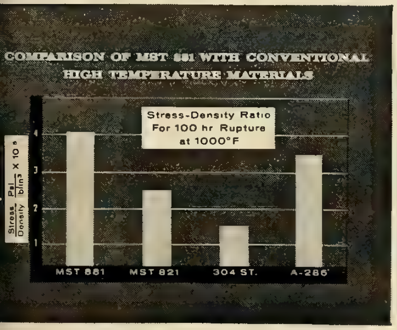
The company was reluctant to di cuss present buyers of the units, b one announcement said the gyro "h already become an important comp nent on the *Atlas, Polaris, Titan* a *Snark* missiles."

New Mallory-Sharon 1100° Titanium Alloy

MST 881



BREAKS THE HEAT BARRIER



ote high stress/density ratio of MST 881 at 000° F., compared to MST 821 alloy, 304 and 286 stainless steels.

isit our Booth No. 1151 at Western Metal Exposition, March -20, Pan-Pacific Auditorium, Los Angeles.

Now, after 2½ years of intensive research, Mallory-Sharon has developed a new titanium alloy with elevated temperature properties far surpassing those of any existing titanium alloys.

What this means in terms of jet engine construction, for example, is illustrated above. The weight-saving advantages of titanium can now be obtained in additional stages of hot Mach 3 engines through use of MST 881.

At a temperature of 1000 degrees F., a level of increasing importance in the aircraft industry, MST 881 has *more than twice the creep strength* of any existing commercial titanium alloy. Even at 1100 degrees F., MST 881 will have only about 0.5% deformation at a stress at 25,000 psi in 150 hours.

Write today for technical data sheet on MST 881.

MALLORY MS SHARON

MALLORY-SHARON METALS CORPORATION • NILES, OHIO

...NEWS IS HAPPENING AT NORTHROP

Latest Astronertial Navigation and Guidan
system is revealed by Dr. William L. Park
Chief of Systems Development at Nortronics,
division of Northrop Corporation.

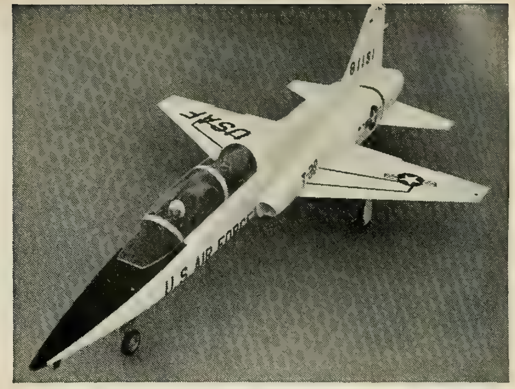
NORTRONICS SYSTEM CAN GUIDE MAN TO PLANETS!

NORTRONICS ASTRONERTIAL: THE ONE GUIDANCE CONCEPT READY NOW FOR THE DAY MAN FIRST EXPLORES THE PLANETS!

NORTRONICS

Astronertial Navigation and Guidance has been under continuous refinement since 1946. The only operational guidance concept capable of interplanetary navigation, it is applicable today to missiles, manned aircraft, surface ships and submarines. Astronertial typifies the years-ahead thinking of Northrop Corporation and all of its divisions. The Corporation's continuing goal: design concepts for tomorrow, hardware for today–in a balanced flow–developed and delivered on time, and at minimum cost.

NORTHROP
CORPORATION
formerly Northrop Aircraft, Inc.
Beverly Hills, California



Now in production, the USAF T-38, America's first supersonic trainer, combines Century-Series performance with unique economy, ease of maintainability.

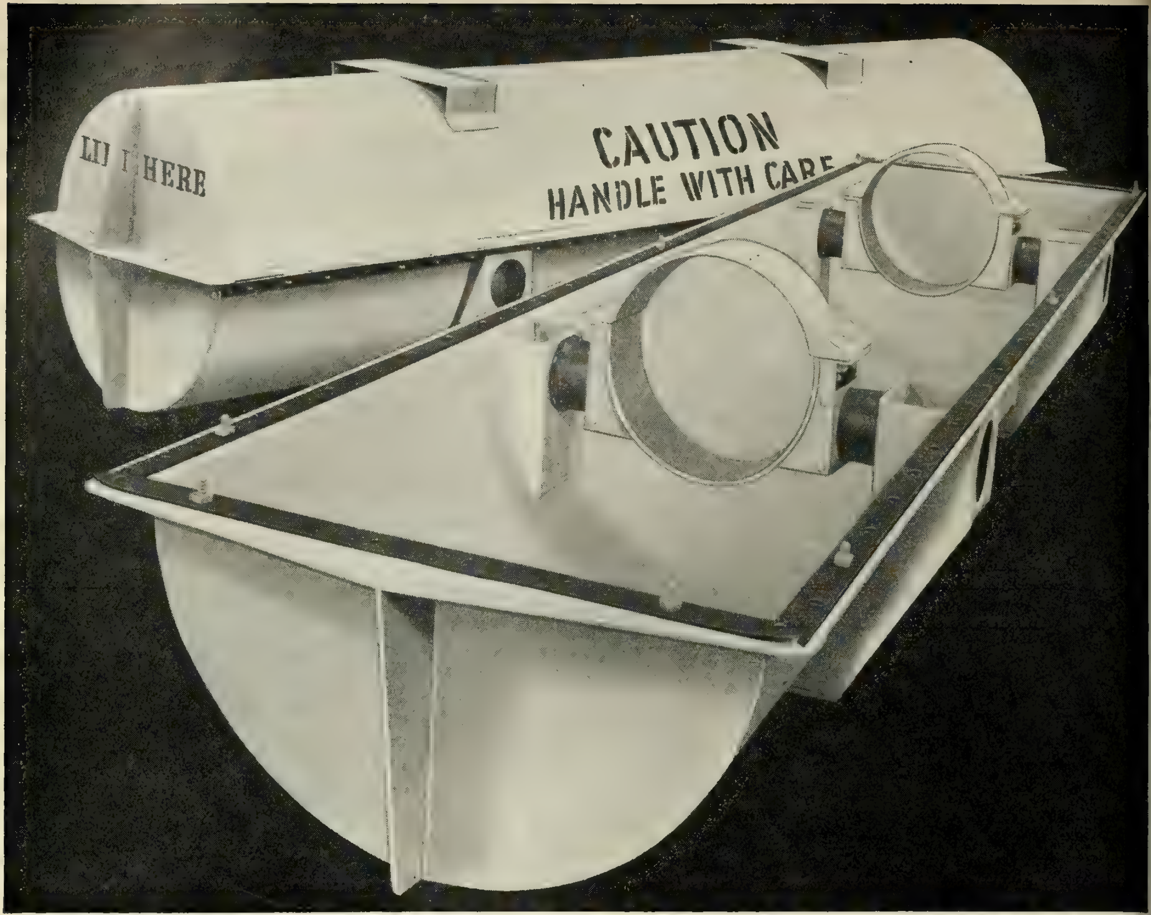
NORAIR

Demanding test for advanced U.S. weapon systems is the XQ-4 supersonic target drone, soon to be followed by the even faster and more sophisticated XQ-4A.

RADIOPLANE

The N-156F counterair fighter is designed to provide friendly free nations effective tactical defense–at little more than half the cost of comparable fighters.

INTERNATIONAL



Shipping and storage container for solid propulsion unit produced by the Thiokol Redstone Division.

METAL FABRICATION PROBLEMS?

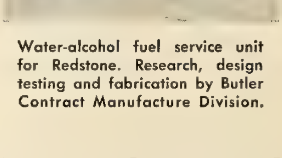
better see Butler

Prime contractors and major sub-contractors in government missile programs find the fastest and most economical way to solve metal fabrication problems is to turn them over to Butler.

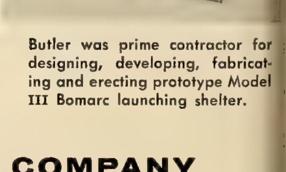
One of the largest fabricators of aluminum and steel with 8 strategically located plants, Butler has proven capability to design, engineer and deliver complex single units or volume production.

Butler is currently producing reusable metal shipping and storage containers for missiles and missile components, and also mobile fuel service units for the Redstone and Jupiter. Butler is participating in developing and producing the first shelters for Bomarc.

For a comprehensive picture of Butler's capabilities and facilities, write:



Water-alcohol fuel service unit for Redstone. Research, design testing and fabrication by Butler Contract Manufacture Division.



Butler was prime contractor for designing, developing, fabricating and erecting prototype Model III Bomarc launching shelter.

BUTLER STEEL PRODUCTS

BUTLER MANUFACTURING COMPANY
BUTLER CONTRACT MANUFACTURE DIVISION
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Two Approaches for Cooling IR Detectors

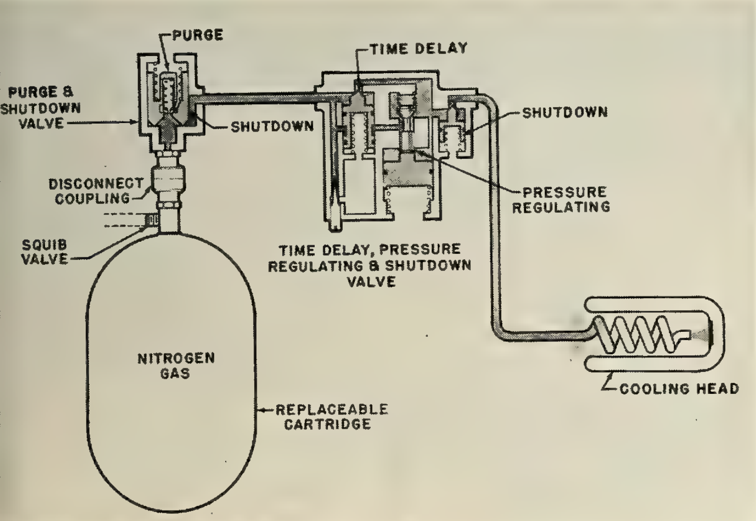
Los Angeles—Two types of cryo- at cooling systems, designed to im- rove the sensitivity and spectral re- onse of infra-red detector units on issiles, have been developed by The arrett Corporation's AiResearch Man- facturing Division, Los Angeles. The ryostats cool the semiconductor ele- ents which detect infra-red radiation roduced by heat from the target which the missile is seeking.

For maximum response to this radiation, the semiconductors must be maintained at an extremely low temperature. The AiResearch systems are capable of maintaining the temperature of a steady –300°F.

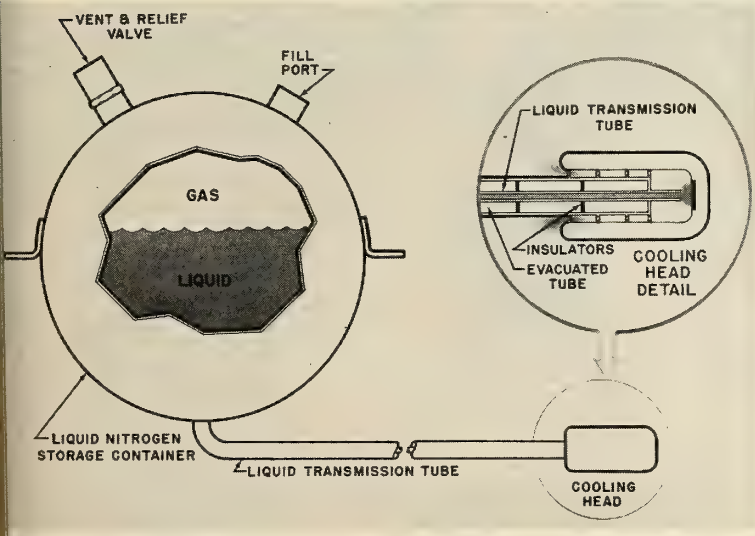
One system uses liquid nitrogen at low pressure with a special Dewar flask. A controlled flow of liquid is transferred from its container by means of a small special insulated tube to the I.R. detector element.

The other method uses nitrogen gas contained at high pressure (3000-5000 psig). The gas, regulated by special valving, travels through an extremely small heat exchanger in the flask where regenerative precooling takes place. Final cooling is accomplished by expanding the gas through an orifice adjacent to the detection element. This expansion causes the gaseous nitrogen to liquify. The latent heat of vaporization is then utilized to maintain the ultra low detector temperature required.

Each system operates in conjunction with a miniature Dewar flask that contains the infra-red detection element in the vacuum annulus. AiResearch is using two methods in the cooling of the elements. One will be liquid and the other will be gas. This diversified approach is expected to come up with the most optimum method of cooling for any given situation. Both liquid and gas models are now being produced by the company.



ITROGEN GAS method used by AiResearch Division of Garrett Corp.



IQUID COOLING system uses insulated tube as transfer means.

Space Requirements Upping Astronomer Needs

Ann Arbor—Space age demands will increase the number of astronomers in the U.S.—who now total 800—at least three or four-fold in the next 10 years, a University of Michigan astronomer predicts.

Recent estimates have indicated the number will double in the next 15 years to more than 1600. But Prof. Leo Goldberg, head of the U-M Department of Astronomy, said the present shortage will get much worse, and doubling the number of astronomers will not ease it.

The most pressing shortage apparently is in the field of celestial mechanics, which deals with the orbits of planets and provides—among other things—the information needed to chart a rocket course to the moon, Mars and Venus, the American Astronomical Society has reported.

Because of limited opportunities for basic research in celestial mechanics, few astronomers have concentrated in it. The advent of satellites and other space vehicles has not changed this situation, but it has created a demand for application of knowledge in celestial mechanics to practical rather than basic problems.

Servo Corp. Manufactures 12-inch IR Dome

LARGEST INFRARED dome manufactured in one piece, which will be used on classified IR search equipment has been delivered to NADC, Johnsville.

NEW YORK—An infrared dome claimed to be the largest manufactured in one piece, destined for use on classified infrared search equipment, has been delivered to the U.S. Naval Ai Development Center, Johnsville, Pa, by Servo Corporation of America, New Hyde Park, Long Island.

The 12-inch, hemisphere-shaped arsenic trisulfide dome will be included in an experimental test vehicle designed to use various infrared detectors i comparative ground and airborn studies of detection capabilities.

The program calls for initial studie to be performed on the ground wit fly-over targets. Pending results of th ground tests, the equipment is to b installed in a nacelle hung on a high performance aircraft and flown at hig altitudes.

Transmitting out to 12 microns, th infrared dome will be able to cove applications in the near through the fa infrared regions. The unit is made o glass which is stable, reportedly doe not deteriorate with use and is non hygroscopic and non-photosensitive. I addition, it should retain its shape with out suffering plastic deformation unde pressure.

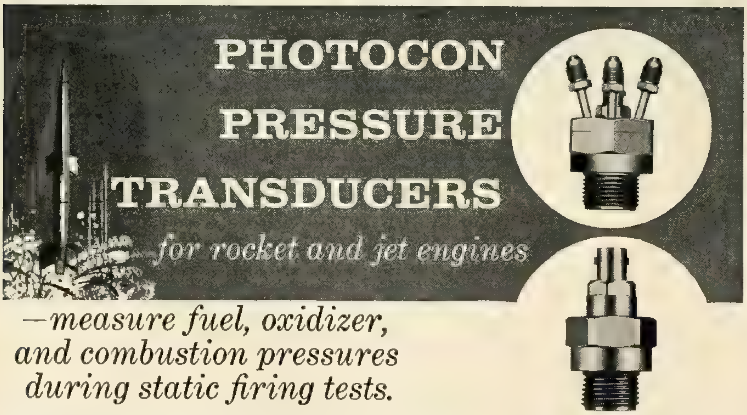
Lockheed Delivers 9-lb. Rugged TV System to ABMA

SUNNYVALE, CALIF.—First units o a tiny battery-powered television sy tem, weighing only nine pounds ye rugged enough to withstand the force of being rocketed into space, have bee delivered to the Army Ballistic Missil Agency by the Lockheed Aircra Corp.'s Missiles and Space Division.

The system, which has a 1000-mil transmitting range, consists of a camer and three small units which easily f into a brief case. The camera itself only 7¾" long and 2¼" in diamete with a weight of 42 ounces, includin lens. Yet its picture transmission qua ity, Lockheed says, compares wi commercial TV cameras and tran mitting stations.

In addition to the camera, the T system includes a transistorized contr unit weighing 42 ounces, a 14-ounc unit containing camera controls an a 50-watt transmitter weighing 4 ounces. It is powered by a 28-volt di cell battery and has been tested to 4 gs of shock, 50 gs of acceleration ar 10 gs of vibration.

• **Surveillance improved**—In th missile field, the miniaturized TV cou be used to follow a missile's perform



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for rocket and jet engines

—measure fuel, oxidizer, and combustion pressures during static firing tests.

High freqency response—units measure static and dynamic pressures over a frequency range of 0-10,000 cps and higher. Pressure ranges: 0-5 psig to 0-100,00 psig.

Easy to install...simple to use. Only three dial adjustments required.

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DYNAGAGE readout instrument—rugged, compact, self-contained...for any Photocon transducer. High voltage output, high signal-to-noise ratio. Standard and miniature sizes.

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Parts for Missiles—Rockets—Jet Engines are constantly calling for newer alloys to operate at higher temperatures. Alloys made by the Midvac process are currently answering these needs and new ones are being developed in anticipation of more critical operations.

Midvac Alloys insure increased tensile and impact properties, improved stress rupture strength at elevated temperature, and longer fatigue life.

Standard commercial alloys can also be made with increased cleanliness resulting in higher properties than have been available under conventional means.

Offered in ingots, billets or forgings for the production of missile combustion chambers, tail cone assemblies, jet engine parts, aircraft landing gear components or any other parts requiring properties beyond the capabilities of conventional steels.

MidVac Steels

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Subsidiary of HEPPENSTALL COMPANY, Pittsburgh, Pa.

ance after it has been launched and has disappeared from sight of ground observers. On a monitor at a ground station you would actually be able to look at such critical things as a stage separation or an engine firing.

Samuel Schwartz, Lockheed research scientist, has patent applications on portions of the electronic design of the system. Initial development was headed by Nicholas K. Marshall, senior scientist. This new piece of space-age hardware was displayed when the Lockheed Missiles and Space Division exhibited some of the advanced scientific research in which it is engaged. "In our current planning," said general manager L. Eugene Root, "we have listed numerous programs as most desirable for LMSD from all aspects of its operations. Some 60% of these are for projects in the space area. Of a large number of proposals submitted by the division in recent months about half have been for space projects."

X-15 Drop Soon

Guidance To Be Tested in Early Program Phase

EDWARDS AFB, CALIF.—The *X-15*, designed to carry man farther into space than he has ever been, will have its first air-borne test this Wednesday, if the present schedule holds.

North American Aviation's Scott Crossfield will crawl into the cockpit of the slender, black experimental craft and be carried aloft for a static test as the *X-15* clings to the right wing of a modified B-52.

About Feb. 27 or 28, the rocket plane will be taken up again—and this time released for its first glide test. The third flight, shortly thereafter, will again be static, to test emergency measures such as releasing fuel from both the *X-15* and the B-52. First powered flight will probably come sometime in mid-April if earlier tests go on schedule.

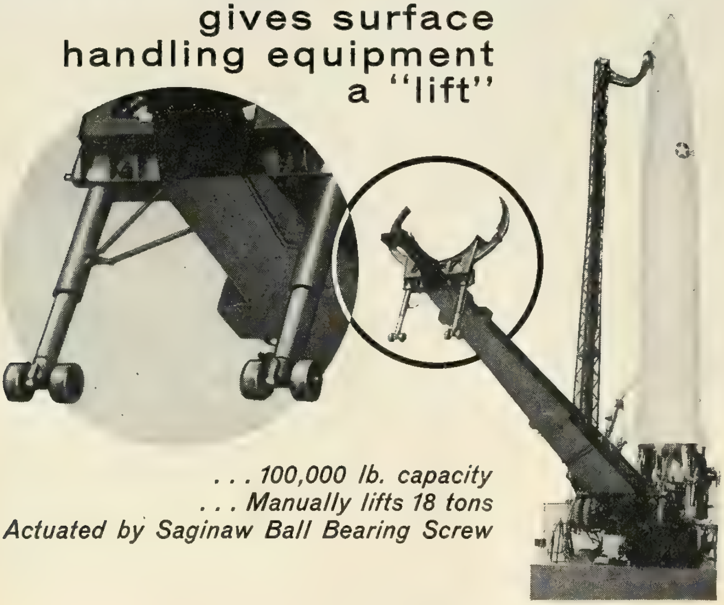
The engines, made by Reaction Motors Division of Thiokol Chemical Corp., were installed in the test plane early in February and have been firing much of the time since.

•Joint project—The *X-15* was built by North American as a joint project for the Air Force and old NACA (now NASA), with the Navy participating. It is 50 feet long, 22 feet at wing span and 13 feet high, with a 31,275-pound launch weight. The plane is designed to reach 100 miles altitude. First flights will be made with two old X-1 engines, later to be replaced by one—the XLR-99. Both engine types were made by Reaction.

Riding in the B-52 which carries the *X-15* will be Capt. Charles C. Bock, pilot; Capt. James E. Allavie, co-pilot, and William Berkowitz of North American, launch pilot. Flying chase will be Capt. Robert White, Air Force test pilot who will actually fly the *X-15* to maximum altitude and speed after Crossfield has tested the initial performance. White will chase first in an F-100F and later in an F-104.

Telemetry of information will be checked out through the master station for high range located in the NASA building at Edwards.

•Sperry guidance—Scheduled for testing in the early phases is the guidance system manufactured by the Sperry Gyroscope division of Sperry Rand Corp. To date, six such systems have been delivered to Edwards. On



BINKLEY Leveling Jack
gives surface
handling equipment
a "lift"

. . . 100,000 lb. capacity
. . . Manually lifts 18 tons
Actuated by Saginaw Ball Bearing Screw

The only practical and economical method of precisely leveling surface handling equipment like the giant Thor transporter-erector is through minute manual adjustment. Binkley engineers custom-designed a leveling jack for Food Machinery and Chemical Corporation to do the job. It was developed through application of the Saginaw Ball Bearing Screw, a General Motors product, with 90% minimum efficiency.

Binkley's extensive experience stems from over 25 years designing and manufacturing truck and trailer body parts and components, including landing gear similar to that shown here. You can benefit from this experience by taking your ground handling equipment problems to Binkley for expert confidential attention.

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KEARFOTT PRECISION RESOLVERS FOR EVERY SYSTEM APPLICATION

Kearfott has available a complete line of precision resolvers for every system application. Computing resolvers range in functional accuracy from .05% to .005%, in bridge accuracy from 3 minutes to 20 seconds of arc and in size from 11 to 25. Non-compensated resolvers range from 5 minutes to 20 seconds of arc in accuracy, from 8 to 25 in size. All Kearfott resolvers feature stainless housing, shafts and bearings and corrosion-resistant lamination materials for maximum environmental resistance. Optional designs available for operation at 200°C and in environment of 2000 cps vibration at 30 g's.

Computing Resolvers

Available with integral compensating windings. Can be provided with trimming networks to match existing isolation amplifiers or Kearfott-designed transistorized amplifiers.

Size 11

For applications where size and good functional accuracy are of paramount importance. Functional accuracy as good as .05% and bridge errors of 3 minutes of arc are in production.

Size 15

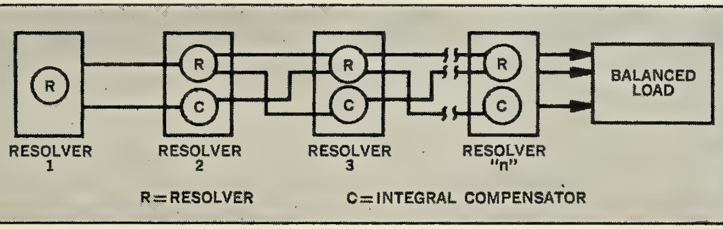
A 2:1 improvement in functional accuracy and bridge error obtained in this configuration. Unit tabulated is the direct equivalent of standard Navy BuOrd Mark 4 Mod 3 and contains necessary trimming network for standard buffer amplifiers. Transformation ratio is 1.000 ± .0001, phase shift 0° ± 1 minute. Functional accuracy of .025% and bridge error of 1.5 minutes of arc are standard.

Size 25

For applications demanding the highest order of accuracy. Close attention has been paid to design parameters.

Size 18

A special resolver which permits a unique cascading of these units without the necessity for buffer amplifiers. Typical application is illustrated in following cascade:



COMPENSATED RESOLVERS FOR PRECISE COMPUTER APPLICATIONS

SIZE	11		15	18	25
PART NUMBER	R980-01	R980-41	T980-51	V980-004	425506-1
Excitation Volts—(Max.)	60	60	26	26	25
Frequency—(cps)	400	400	400	400	400
Primary Impedance	629 + j2510	450 + j2200	220 + j1000	3000 + j (0 ± 40)	1630 /78.5°
Secondary Impedance	695 + j2750	500 + j2300	240 + j1100	3000 + j (0 ± 40)	1620 /80°
Transformation Ratio (Primary to Secondary)	.980	.980	.980	.775	.980
Transformation Ratio (Compensator to Rotor)	.985	.985	.950	.775	.985
Phase Shift (Lead)	8.5°	7.5°	8.5°	0° ± 10′	1°
Fundamental Null (MV)	15	15	8	15	15
Bridge Error From E.Z. (Max.)	7 mins.	5 mins.	3 mins.	3 mins.	20 Seconds
Primary	Stator	Stator	Stator	Stator	Stator

Non-Compensated Resolvers

Basically for application in precise data transmission systems. These synchro resolvers permit system designer to achieve system errors of better than 1 minute of arc without using 2-speed servos and elaborate electronics. By proper impedance matches up to 64 resolver control transformers can also operate from one resolver transmitter.

Size 11

Where size is important. These units have a maximum unit error of 3 minutes of arc.

Size 25

Where highest accuracy is required. These units have a maximum error as low as 20 seconds of arc.

NON-COMPENSATED RESOLVERS FOR PRECISE DATA TRANSMISSION

	SIZE 11			SIZE 25		
Type Resolver	Transmitter	Differential	Control Transformer	Transmitter	Differential	Control Transformer
Part Number	R982-004	R982-011	R982-012	Z5161-001	Z5191-001	Z5151-003
Excitation Volts (Max.)	26	11.8	11.8	115	90	90
Frequency (cps)	400	400	400	400	400	400
Primary Impedance	170 /77°	850 /80°	2000 /80°	400 /80°	800 /80°	8500 /80°
Secondary Impedance	42 /80.5°	1000 /79°	8000 /76°	260 /80°	900 /80°	14000 /80°
Transformation Ratio	.454	1.000	1.906	.7826	1.000	1.278
Max. Error from E.Z.	3 mins.	3 mins.	3 mins.	20 seconds	20 seconds	20 seconds
Primary	Rotor	Stator	Stator	Rotor	Stator	Stator

Write for complete data.

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GENERAL PRECISION EQUIPMENT CORPORATION
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BURROUGHS COMPUTATION GUIDES ATLAS INTO ORBIT

Back of the history-making Burroughs computation that guided the Atlas Satellite into orbit—and that also guides the big bird to its earthbound targets—lies a dedication to continuing advancement. Coming: even greater developments geared to the mounting challenge of the space age.

Burroughs Corporation

"NEW DIMENSIONS / in computation for military systems"

this week's m/r cover, Dr. Carl A. Frische, president of Sperry, and Nathan P. White, section head for the *X-15* system program, examine the stabilized platform which is the heart of the inertial system. The blackboard equation refers to velocities which will be encountered during the *X-15* missions.

Inertial guidance was chosen for the *X-15* because, all other factors being approximately equal, the sole limiting factor with an inertial system was flight duration—and even this could be improved with better components.

The present system can be divided by functions into two groups. The first group, carried in the *X-15*, consists of the platform, the computer, and indicators. The second group, located within the B-52, supplies the proper initial conditions to the computer prior to launch.

•**Elaborate equipment**—The platform has three gyros for stabilization and three accelerometers for measurement of velocity, altitude, position and attitude relative to the earth. It is maintained normal to the geographic vertical and, because of the extreme altitude and velocity changes of the *X-15*, all accelerations due to kinematic velocities and changes in the earth's mass attraction force are computed and nserted into the system.

Ten transistorized amplifiers to operate the gyros, accelerometers and gimbal servos are located on the platform. There are four gimbals—roll, pitch, inner roll and azimuth.

The pitch, inner roll and azimuth axes are maintained mutually perpendicular. The outer roll axis is gimballed with respect to the fore-aft aircraft axis and operates in conjunction with he inner roll axis to produce an angular displacement proportional to aircraft oll attitude. The redundant roll axis allows the *X-15* unlimited motion about any degree of freedom without the possibility of gimbal lock or loss of verticality.

The computer provides a number of functions including Doppler inertial mixing, gyro drift storage, acceleration o velocity integration, velocity to position integration, earth rate computations and acceleration corrections due o kinematic velocities.

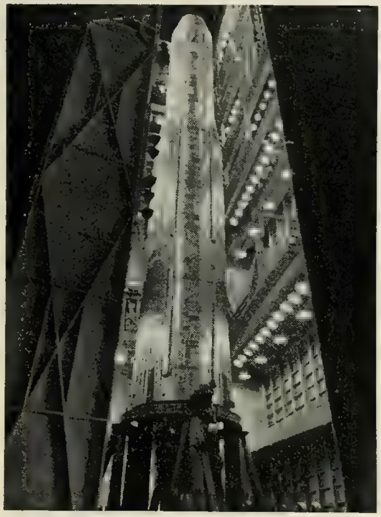
The unit is constructed with two basic building blocks. One of these is precision integration that uses a DC achogenerator as the accuracy-determining element. The integrators are ackaged in two groups of three each position integrator group and velocity ntegrator group) and include all electronic accessory equipment.

Martin-Baltimore Reorganized

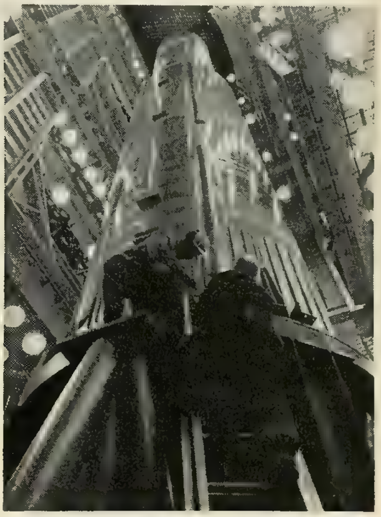
BALTIMORE — Martin-Baltimore — breaking sharply with traditions of the aviation industry, has reorganized its 2,000-man engineering organization into separate "task forces."

Replacing the previous single engineering division are two new organizations—Manned Vehicles and Missiles-Electronics. The first division will include manned aircraft of conventional and advanced types.

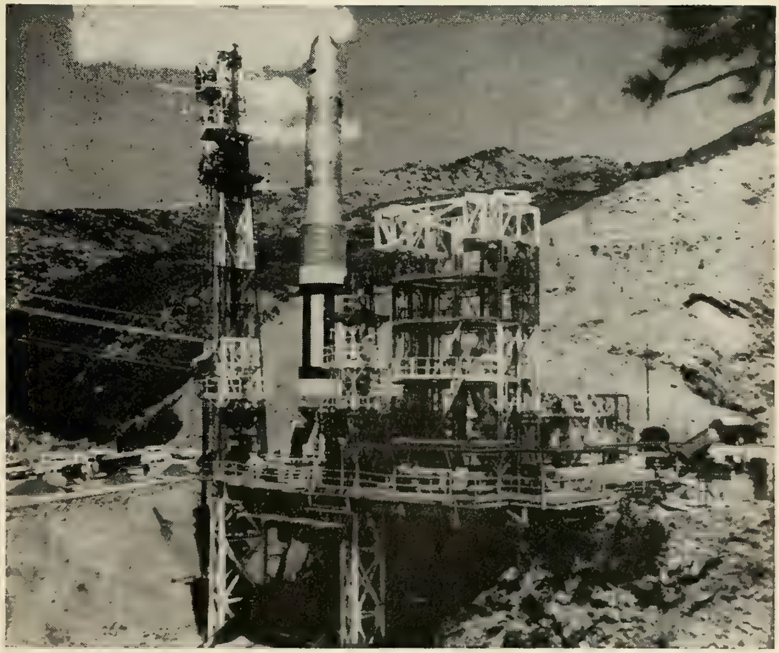
Frederick R. Dent, Jr., retired Air Force major general and former chief of the Wright Air Development Center, has been named head of Missiles and Electronics Engineering. Herman Pusin, former chief engineer of the Baltimore Division, has been appointed to direct the Manned Vehicles Engineering Division.



MARTIN-DENVER'S *Titan* **undergoes checkout in Vertical Test Laboratory.**



LOOMING UP 13 stories, *Titan* **is checked for interconnection of all subsystems.**



Titan **UNDERGOES static test in mountains at Colorado facility.**

REDUCE
BREAKDOWN FAILURES

NEW
WELWYN
MOLDED
DEPOSITED CARBON RESISTORS

The use of a thermo-plastic insulation material has resulted in an economically priced molded carbon resistor of markedly improved endurance and long term stability.

Type N resistors subjected to several one-hour cycles of immersion in boiling water — while DC polarized — have revealed only negligible changes in resistance. Continuous operations at 150°C caused no damage to the component.

The new Type N resistor, a deposited carbon film fired onto a porcelain rod, is first tropicalized with multiple coatings of panclimatic lacquers to give it long term moisture resistance, and is then molded in a thermo-plastic material.

This molded insulation has an effective resistance in the order of 10^{13} ohms. Its inherent thermal conductivity is approximately ten times that of air, resulting in substantially improved load life under conditions involving excessive or high wattage dissipation. Similarly, Type N resistors may be soldered as close to the insulation as desired without fear of melting or deforming the cover.

One added advantage of the Type N is that the original markings on the resistor body remain visible and legible through the transparent molded material.

Welwyn Type N carbon resistors meet the requirements specified by MIL-R-10509B, and are available in all values, ranging from 10 ohms through 1 megohm. For complete data and specifications write to Welwyn International, Inc., 3355 Edgecliff Terrace, Cleveland 11, Ohio.

SAMPLES AVAILABLE ON REQUEST.

letters

Budget Figures

To the Editor:

Has any other reader of your fin and necessary magazine pointed ou several discrepancies in the charts o pg. 21-23 of the Jan. 26 issue?

Page 21—Col. 1, 22,477 + 20,23 = 42,708 not 42,709; Col. 4, 8,492 + 10,817 = 19,309 not 19,308; Col. 6 22,319 + 19,030 − 405 = 40,944 no 40,945; Col. 8, 6,625 + 5,727 + 15 = 11,597 not 11,596.

Page 22—1960 estim col. 3, 18, 000,000 + 128,100,000 + 307,900,00 + 21,900,000 = 455,000,000 no 445,000,000.

Page 23—Est. 1960, 1958 actua 25027 + 16561 = 41,588 not 41,587

Missile Expenses: 344.4 + 442.5 + 904.3 + 17.4 + 132.1 + 179.1 + 323.6 + 135.1 + 34.2 = 25,127 no 25,027.

Also in text col. 3, page 21, Army 9.35 billion should be 9.53 billion From Col. 7, page 21, 7,108 + 2,42 = 9,530.

Would appreciate knowing if an other reader has apprised you of th above. Thank you and sincere bes wishes.

Frank W. Finnegan
400 Butler St.
Brooklyn 17, NY

The tables referred to are official an correct. For conciseness, Defens budgeteers omitted amounts of le than half a million so that the tota do not exactly agree with the sums the columns. The figure $445 millio is a typographical error and should b as Reader Finnegan notes, $455 mi lion. The $9.35 billion figure for Arm is correct as given for Army's ne obligational authority (not expenditures

Star-Cross?

To the Editor:

ASTROPHOBIA
Integrating image tubes
Cosmic intensification
Trajectories and orbit planes
Descent of mass acceleration
Occluded stars, orbital paths
Computed force of gravitation
I'd do my typing on the moon
To rid myself of this aggravation!

I wrote this verse as a tribute the pioneer-secretary employed in t ever-rising branches of astronauti sections throughout the U.S.

Lois Utz
Astronautics Anonymo
130 Park Place
Pompton Lakes, N. J.

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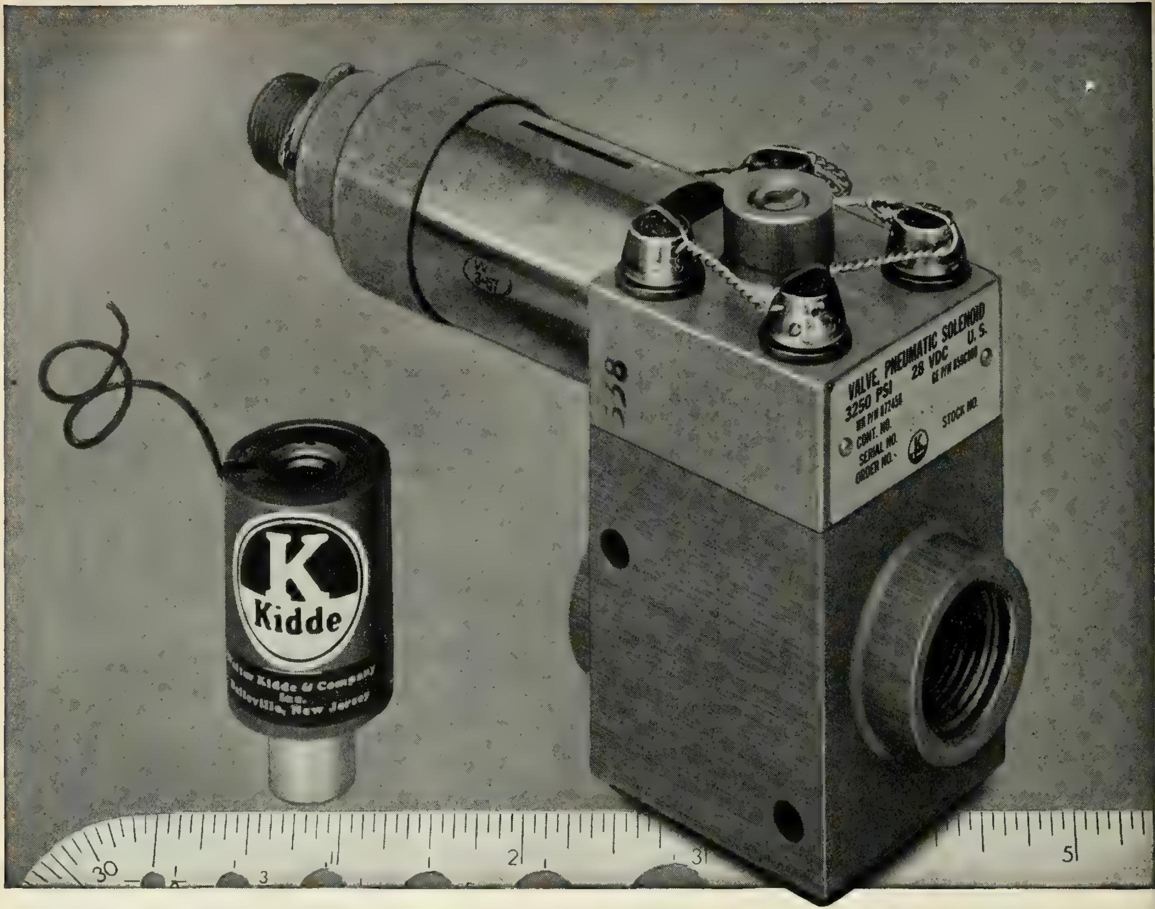
UNITED AIR LINES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For more information on these new tested and proven valves, as well as more than 100 qualified pneumatic system components, write to Walter Kidde & Company—pioneers in aircraft pneumatic systems, and *still* first with the finest in pneumatic components!

KIDDE VALVE #872071 (The tiny one)

Operating Pressure	0-3000 psi
Temperature Range	−75°F. to +350°F.
Leakage	3 cc/hr.
Flow	Equivalent to .05 orifice.
Operating Current	.5 to 1.5 amps.
Operating Voltage	14-30 V.D.C.
Mounting	by tubing support
Life	100 to 10,000 cycles depending on operating conditions.
Weight	.19 lbs.

KIDDE VALVE #872458 (The speed demon)

Operating Fluid	Dry air/nitrogen gas
Operating Pressure Range	80 to 3250 psi
Proof Pressure	4875 psi
Burst Pressure	8125 psi minimum
Ambient Temperature Range	−65°F. to +160°F.
Flow Factor	1.37
Voltage Range	18 to 30 V.D.C.
Current	(28 V. @ 80°F.) 1.2 amps.
Coil Resistance	(80°F.) 21.5 to 24 ohms
Weight	1.40 lbs
Response Time	0.018 seconds

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propulsion engineering

by Alfred J. Zaehringer

Piping LOX and other cryogenic fluids over long distances can be made easier with equations and empirical studies now made available by the National Bureau of Standards. Such information is expected to play a leading role in designing hard ICBM bases for *Titan.*

About 20% of U.S. LOX output now goes into missiles. Total yearly use—government and industry—is pegged at 80-100 billion cubic feet. Low purity LOX goes for $10-15 per ton while high purity sells for $30-50 per ton. This year, oxygen sales should hit $150 million.

First private helium plant may portend increased availability for missiles and rockets. A $13.5-million helium extraction plant is being built by Helex Co. (a joint venture of Northern Natural Gas and Air Products) at Sunray, Tex. Helium at present is under governmental control and has been in relatively short supply.

Modular rocket design is being proposed on several fronts to increase reliability and relax stringent design requirements of present liquid propellant missiles. Standard tanks would be connected to manifolded or clustered standard engines. Though this concept could be applied to a large number of mission requirements, it would generally result in a larger missile for a particular mission than a specially-designed, optimized missile. The building block concept would, however, speed development and production of large space vehicles. Clustered 1.5-megapound-thrust *Jupiter* engines, now under development, may allow such modular rockets.

Thrust control for rocket engines developed by Bendix Products Div., South Bend, Ind., measures rate of change of chamber pressure plus chamber pressure and compares it with a variable reference to generate an error signal. Signal drives a power piston. System is designed to limit thrust overshoot which might result during a severe starting transient.

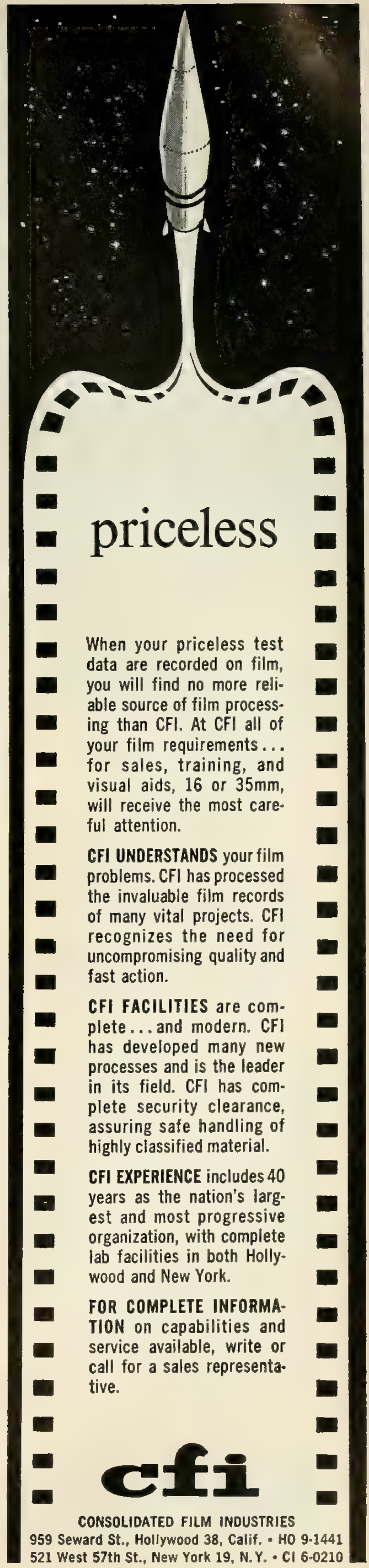
Rocket nozzles and other hot components can be fabricated from Avocite, a quasi-ductile reinforced ceramic for use at 5000°F. Developed by Avco, the material resists heat shock and high-temperature gas erosion. Tests have been made with both liquid and solid propellants.

Boron trichloride, a vital intermediate in the manufacture of boron fuels, will get close scrutiny through a joint venture of Dow Chemical and US Borax Research Corp. Economical production would mean lower boron fuel costs. Another significant aspect of this joint program is that Dow has an ARPA solid propellant research contract and US Borax Research has been working toward inorganic boron polymers for solids.

Ultra-fine aluminum powder with average particle size of 300 Angstroms is looked on by National Research Corp. as a potential additive for solid or gel propellants. Other possibilities: burning rate increases because of small particle size, or combustion catalyst.

Double-base solid propellant for *Polaris* missile is being worked on jointly by Allegany Ballistics Laboratory and Naval Propellant Plant. The latter facility, formerly the Naval Powder Factory, is recovering from a recent drastic cutback in operation. Composite propellant for *Polaris* is now being worked on by Aerojet-General.

Solid lubes—in film form—can take 1800°F. Expected to be of value for solid rocket engines, APU's, and other propulsion hot spots, the inorganic lubes were developed at Washington State Institute of Technology.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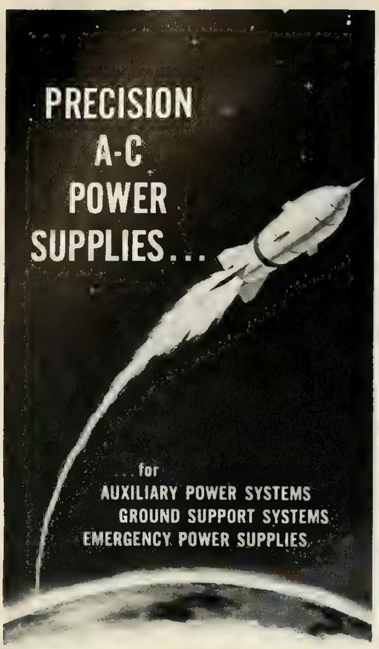

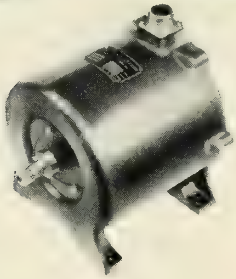

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missile business

by Reed Bundy

The Air Force has warned manufacturers that it expects to spend less money per unit on missiles and components in the future with its "building block" approach to weapon systems. It says companies that want to continue getting AF business must cut controllable costs, make accurate bids, deliver on time, and do as much R&D work as possible on their own.

"It appears that controllable costs have risen at a higher rate than has performance," Lt. Gen. C. S. Irvine, AF Deputy Chief of Staff for Materiel, recently told the Northrop T-38 Suppliers Symposium in Los Angeles. "It is not enough," the top AF procurement officer declared, "that prime contractors or system managers improve their management technique so as to reduce costs. First, second, and third-tier sub-contractors must do likewise. This applies whether the company is large or small; there is always room for improvement."

Irvine said a company bidding for a contract "should make certain that its proposed costs are factual and accurate. Estimates, no matter how valid they may appear, are not sufficient. When the Air Force commits itself to obligate taxpayers' dollars, it must do so with every assurance that the price is as low as can be reasonably obtained."

Delivery on time is another "absolute must," Irvine said. But he stressed that delivered items must reflect the lessons learned in tests—not "blind adherence to initial design" that would guarantee on-time delivery.

A third "must," according to Irvine, is company-supported research and development. Most-likely contract recipients, he said, will be those "who have enough initiative not to wait for subsidies before going ahead on their own . . ."

A new mechanical manufacturing information system (MMI) has been developed by Westinghouse Electric Corp. to save money and cut the time required to get defense hardware from drawing board into production. The company says the system, involving specially-designed semi-automatic and automatic business machines, will save its Air Arm Division about $500,000 by 1962 in paperwork processing costs alone. Under conventional systems, basic data on new military products is passed from one operating section of a company to another. In the MMI system, the information is put on perforated tape, with data needed by each department issued simultaneously on tape or punched cards, so that purchasing can begin to buy materials while manufacturing is preparing to process them.

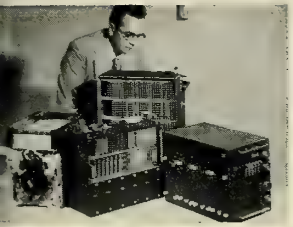
DOD and NASA have asked Congress for authority to insure their contractors against "unusually hazardous" risks in nuclear, missile and volatile fuel programs. The requested authority, limited to a 10-year period, would provide for a maximum indemnity of $500 million for any one incident.

Some government contractors would lose their immunity from state and local taxes under a bill reintroduced by Sen. Strom Thurmond (D-S.C.). The bill, which passed the Senate in the 85th Congress, reportedly is aimed mainly at firms which buy materials in the name of the Federal government, and fabricate them into products which will belong to the government.

A wave of acquisitions and mergers reflects industry's effort to keep up with the growing needs of missilery. Monogram Precision Industries, Inc., of Culver City, Calif., has acquired Lamatic Co., of North Hollywood, from Angelus Industries, Inc. . . . Electronic Communications, Inc., of St. Petersburg, Fla., acquired by merger Standard Products, Inc., of Wichita, Kan. . . . Airtek Dynamics, Inc., of Los Angeles, purchased Research Welding & Engineering Co., Inc., of Compton, Calif. . . . Metal Glass Products Co., of Elkhart, Ind., became a subsidiary of Barler Metal Products, Inc., of Goshen, Ind. . . . Firth Sterling, Inc., of Pittsburgh, Pa., bought the Kellogg specialty alloy steel manufacturing business from The M. W. Kellogg Co., of New York City.

third in a series

THE DIVISIONS OF THOMPSON RAMO WOOLDRIDGE INC.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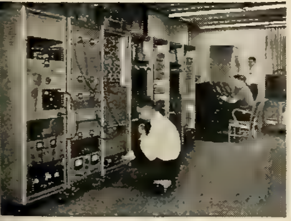
ew type of radar data processing system
eveloped by R-W materially increases the
ipabilities of ground defense radar

RAMO-WOOLDRIDGE

While it is now a division of **Thompson Ramo Wooldridge Inc.** instead of a separate corporation, **Ramo-Wooldridge** remains an integrated organization for research, development, and manufacture of electronic systems for military and commercial applications. R-W's military work is covered by thirty-four contracts with the Army, Navy, Air Force, and other government and industrial organizations. These support a broad technical and—in some cases—manufacturing program in such varied fields as Electronic Reconnaissance and Countermeasures; Microwave Techniques; Infrared; Analog and Digital Computers; Air Navigation and Traffic Control; Antisubmarine Warfare; Electronic Language Translation; and advanced Radio and Wireline Communication.

In the commercial field, the well-known RW-300 industrial process control computer and associated equipment—the basis of the expanding business that **The Thompson-Ramo-Wooldridge Products Company** is doing with process industries—was developed and is manufactured by the Ramo-Wooldridge division.

Men, machines, and manufacturing know-how from other TRW divisions will be added as needed to build up the growing production strength of the Ramo-Wooldridge division. In other ways, too, the availability of the special skills and facilities of the rest of the corporate family will broaden the services R-W can offer to its customers. However, R-W's major systems work will continue to be done in an organizational framework that brings the engineering and manufacturing groups into close-knit project teams in the division's own integrated development and manufacturing facilities in both Los Angeles and Denver.

Ramo-Wooldridge is production-oriented in the sense that its end objective is the manufacture and sale of equipment. However, because of the highly technical nature of its product lines, the R-W division will continue to give unusual emphasis to maintaining a high degree of professional scientific and engineering competence.

The RW-300 digital control computer has broad applications in automatic process control, data reduction and test facility operation

Systems are being developed for the ground processing and interpretation of photographic and other data collected by aerial reconnaissance devices

The Military and Ramo-Wooldridge are studying the use of automatic data processing techniques

In research laboratory studies at Ramo-Wooldridge, electrically-charged particles are contained and supported in a vacuum by an alternating electric field

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contract awards

ARMY

$50,731,000—**Raytheon Manufacturing Co.,** for production of *Hawk* system.

$5,000,000—**Sylvania Electric Products Inc.,** for development and production of three additional MOBIDIC computers and programing assistance (four contracts).

$1,450,000—**California Institute of Technology,** for R&D (two contracts).

$1,247,403—**Jefferson Construction Co.,** Miami, for construction of Eglin Gulf Test Range.

$1,240,428—**Western Electric Co., Inc.,** for *Nike* spare parts and components (13 contracts).

$1,120,000—**Douglas Aircraft Co., Inc.,** for supplies, services and repair parts (two contracts).

$596,369—**Radioplane Co.,** Van Nuys, Calif., for target drones.

$303,458—**Motorola, Inc.,** Phoenix, for telemetry sets.

$150,000—**Columbia University,** for analysis of radar noise in *Nike* and related systems.

NAVY

$1,300,000—**Allen B. Du Mont Labo**
atories, Inc., Clifton, N.J., fo
production of 22 universal missil
test sites for *Sparrow III* progra
(sub-contract from Raytheon Mf
Co.).

$609,353—**Eitel-McCullough, Inc.,** Sa
Carlos, Calif., for electron tube
(four contracts).

$500,000—**Aeronutronic Systems, Inc**
Glendale, Calif., a subsidiary
Ford Motor Co., for instrumenta
tion planning for the Pacific Mi
sile range. Six-month study to
carried out by Aeronutronic an
its associated contractors—**Coo**
Research Laboratories, Dunlap
Associates, Eastman Kodak C
and **Page Communications Eng**
neers.

$500,000—**Federal Pacific Electri**
Co., Newark, N.J., for electrica
equipment for missile sites
Vandenberg AFB and Pt. Arguell
Calif.

$493,372—**Walker Electrical Co., Inc**
Atlanta, for *Tartar* missile switch
board, gunnery switchboard an
underwater battery switchboards.

$194,530—**General Electric Co.,** fo
electron tubes (four contracts).

AIR FORCE

$985,109—**Collins Radio Co.,** Dalla
for labor and material to provid
microwave communications syste
between central missile comman
facility at Warren AFB and fou
remote missile launch sites.

$900,000—**The Martin Co.,** for in
plementation program for *TM-76*
missiles.

$723,118—**Raytheon Mfg. Co.,** f
electron tubes.

$500,000—**Bogue Electric Manufactu**
ing Co., Paterson, N.J., for d
velopment and production of ultr
sonic fuel measuring and contr
system for *Titan* (sub-contract fro
The Martin Co.).

$307,766—**Tung-Sol Electric In**
Newark, N.J., for electron tube

$225,000—**Beckman Instruments, In**
Berkeley, Calif., for high-spe
analog computer for *Bomarc* sy
tem (sub-contract from Boeing A
plane Co.).

$209,568—**Wood Electric Co.,** Ne
buryport, Mass., for circ
breakers.

$168,825—**Sylvania Electric Produc**
Inc., for electron tubes.

$160,528—**Eitel-McCullough, Inc.,**
electron tubes.

$105,993—**Aeronautical Div., Minn**
apolis-Honeywell Regulator C
for research study on non-ma
netic stable platform for use
connection with magnetome
measurements from *Aerobee*
sounding rockets.

...operations research

Future advancements in missile and space technology are largely dependent on activities today in operation research. At Lockheed, operations research scientists explore future programs, evaluate the objectives and requirements of new proposals, establish parameters for the most effective procedures, determine specifications, perform preliminary design and analysis and originate proposals for both immediate and long term development.
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missile people

Dr. Hubertus Strughold, Advisor
; Research and Professor of Space
edicine at the Air Force School of
viation Medicine, has been named the
58 winner of the Dr. John J. Jeffries
vard for his outstanding contribu-
ns in space and aviation medicine
search. Dr. Strughold is a con-
buting editor to m/r.

The award, one of the highest and
ost coveted in the aero-medical field,
presented annually to the individual
ponsible for outstanding contribu-
ns to the advancement of aero-
utics through medical research.

Howard P. Mason, formerly Aero-
General's coordinator of the *Titan*
ogram and more recently executive
sistant in the company's Missile
nge Division, has been appointed
rojet's Corporate Base Manager for
Pacific Missile Range. He will co-
dinate Aerojet's activities at Vanden-
rg Air Force Base, the Naval Missile
cility—Point Arguello—and range
erations at the Navy's Missile Test
nter, Point Mugu.

The Air Force has announced ap-
intment of **Dr. Jack P. Ruina** as
puty for Requirements to the Assist-
t Secretary, Research and Develop-
ent. Dr. Ruina previously served with
University of Illinois as Associate
ofessor of the Department of Elec-
cal Engineering and as Research
sociate Professor of the Control
stem Laboratory.

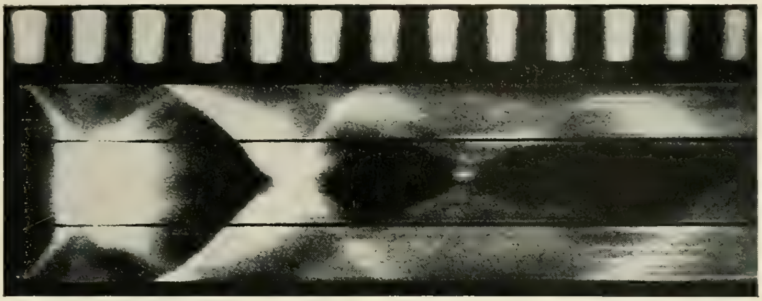
J. M. Gruitch has been appointed
the newly created post of director
government products of ACF In-
stries, Inc. He was formerly director
defense products for ACF's Ameri-
Car and Foundry division.

Dr. Thomas J. Carroll, authority
the electronic phenomenon known
twilight scatter propagation, has
en a new post at the Radio Divi-
n of Bendix Aviation Corp. He will
ve on the Advanced Development
ff of the division's Government
oducts Group.

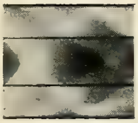
Ralph W. Waniek, formerly senior
entist at Harvard University and
T's Cambridge Electron Accelerator,
been appointed Director of Re-
rch of the Magnetohydro-dynamics
boratory recently organized at Gian-
i Plasmadyne Corp.

Dr. Hans Wolfhard has joined the
earch staff of Thiokol's Reaction
otors Division as manager of the
ysics Department. Dr. Wolfhard, a
ysics and combination research ex-
t, will be responsible for the tech-
ogical advancement in the field of
ysics.

REPORT ON *Plasma Propulsion at Republic Aviation*



Space-Time Trace: With space as ordinate and time as abscissa, photograph shows development of pinch effect in plasma, followed by shock waves. Picture was obtained with special streak camera — part of the instrumentation devised for Republic's experimental Plasma Propulsion program. Each space at top measures an interval of 10 microseconds.



An experimental Plasma Propulsion System under test at Republic Aviation gives promise of a power plant ideally suited to space vehicles. The system generates plasma from a heavy gas and subjects it to magnetic acceleration to produce thrust at high exhaust velocity.

Research and Development in Plasma Propulsion and in a number of branches of Hydromagnetics and Plasma Physics is being sharply expanded as part of Republic's new $35,000,000 Research and Development Program. Investigations currently in progress include studies of plasma generation of electricity and the application of Hydromagnetics to Hypersonics.

Opportunities to Lead Theoretical and Experimental Research

The Scientific Research Staff welcomes the affiliation of scientists and engineers of stature in the following fields:

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GASEOUS ELECTRONICS
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HIGH POWER PULSE ELECTRONICS

Salaries commensurate with the high degree of talent and creativity required. You work with stimulating associates in a laboratory atmosphere. $14,000,000 of additional facilities now being built for Republic's new Research Center in suburban Long Island.

Write in confidence directly to:
DR. THEODORE THEODORSEN, *Director of Scientific Research*
REPUBLIC AVIATION
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IMPORTANT ANNOUNCEMENT TO ALL ENGINEERS—EE, ME, AE, CE:

A New Organization Now Forming at General Electric to Integrate and Direct Systems Management of Prime Defense Programs

From within General Electric, and from industry at large, talented scientists and engineers from diverse disciplines are coming together to form the nucleus of the new Defense Systems Department.

The responsibilities of this new group encompass management of theoretical and applied research as well as advanced development on major terrestrial and space-age systems.

Engineers and scientists interested in exploring the broad new possibilities in the Defense Systems Department are invited to investigate current openings.

Direct your inquiry in confidence to Mr. E. A. Smith Section 2-G

DSD

DEFENSE SYSTEMS DEPARTMENT
GENERAL ELECTRIC
300 SOUTH GEDDES SREET
SYRACUSE, NEW YORK

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when and where

FEBRUARY

IRE, AIEE 1959 Solid State Circuits Conference, University of Pennsylvania, Philadelphia, Feb. 12-13.

Conference for Manufacturing and Engineering Management, Computer and Data Processing in Industry, Purdue University, Lafayette, Ind., Feb. 12-13.

Heat Transfer Div. of American Society of Mechanical Engineers, Third Annual Symposium on Thermal Properties, Purdue University, Feb. 23-26.

EIA Sixth Industrial Relations Conference, Chase-Park Plaza Hotel, St. Louis, Feb. 25-27.

1959 Engineering Exposition, Balboa Park, San Diego. For information, contact exposition office at 422 Land Title Bldg., San Diego. Feb. 26-Mar. 1.

MARCH

IRE, AIEE and Association for Computing Machinery, 1959 Western Joint Computer Conference, Fairmont Hotel San Francisco, March 3-5.

Institute of the Aeronautical Sciences, Flight Propulsion Meeting (classified), Hotel Carter, Cleveland, March 5-6.

Second Western Space Conference and Exhibits, Great Western Exhibit Center, Los Angeles, March 5-7.

Gas Turbine Division of the American Society of Mechanical Engineers, Turbine in Action, Cincinnati, March 8-11.

Third Annual Shock Tube Symposium, Old Point Comfort, Ft. Monroe, Va. For details: Armed Forces Special Weapons Center, Kirtland AFB, Albuquerque, N.M. Attn.: SWRS R. R. Birnoff. March 10-11.

American Society for Metals, 11th Western Exposition and Congress, Pan-Pacific Auditorium and Ambassador Hotel, Los Angeles, March 16-20.

American Rocket Society, 1959 Sectional Meeting, Daytona Plaza Hotel, Daytona Beach, Fla., March 23-25.

CONVAIR'S B-58 HUSTLER and CONVAIR'S ATLAS ICBM

PARTNERS FOR PEACE... manned and unmanned!

Long range planning of yesterday by the U. S. Air Force is taking shape today in *manned and unmanned* weapons systems such as Convair's B-58 Hustler—our *first supersonic bomber;* and Convair's Atlas—the *free world's first Intercontinental Ballistic Missile!* In utilizing the outstanding features of both systems, this unmatched combination offers the Air Force maximum flexibility in carrying out its Strategic Mission. These *partners for peace,* both *manned and unmanned,* integrated into a single instrument of defense, play a vital role in keeping the free world free!

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On a 300 acre site in Maryland, Thiokol's Elkton Division pursues advanced programs of basic and applied rocket research, development and production.

In current production are rockets for low altitude cockpit ejection systems. One such device — powered with a Thiokol rocket — has been instrumental in saving life in two emergencies.

Nucleus of Thiokol's rocket team was organized at Elkton in 1948. *Recruit*, solid propellant rockets for "Operation Farside" and *Cajun*, for upper atmosphere research, are marked milestones in Elkton's progress.

Equipped with the most modern laboratory, production and testing facilities . . . the Elkton Division is engaged in the development of advanced rocket motors of diversified size and type, of high energy fuels — and their adaptation to military and civilian use.

Scientists, Engineers: perhaps there's a place for you in Thiokol's expanding organization. Our new projects present challenging problems and a chance for greater responsibility.

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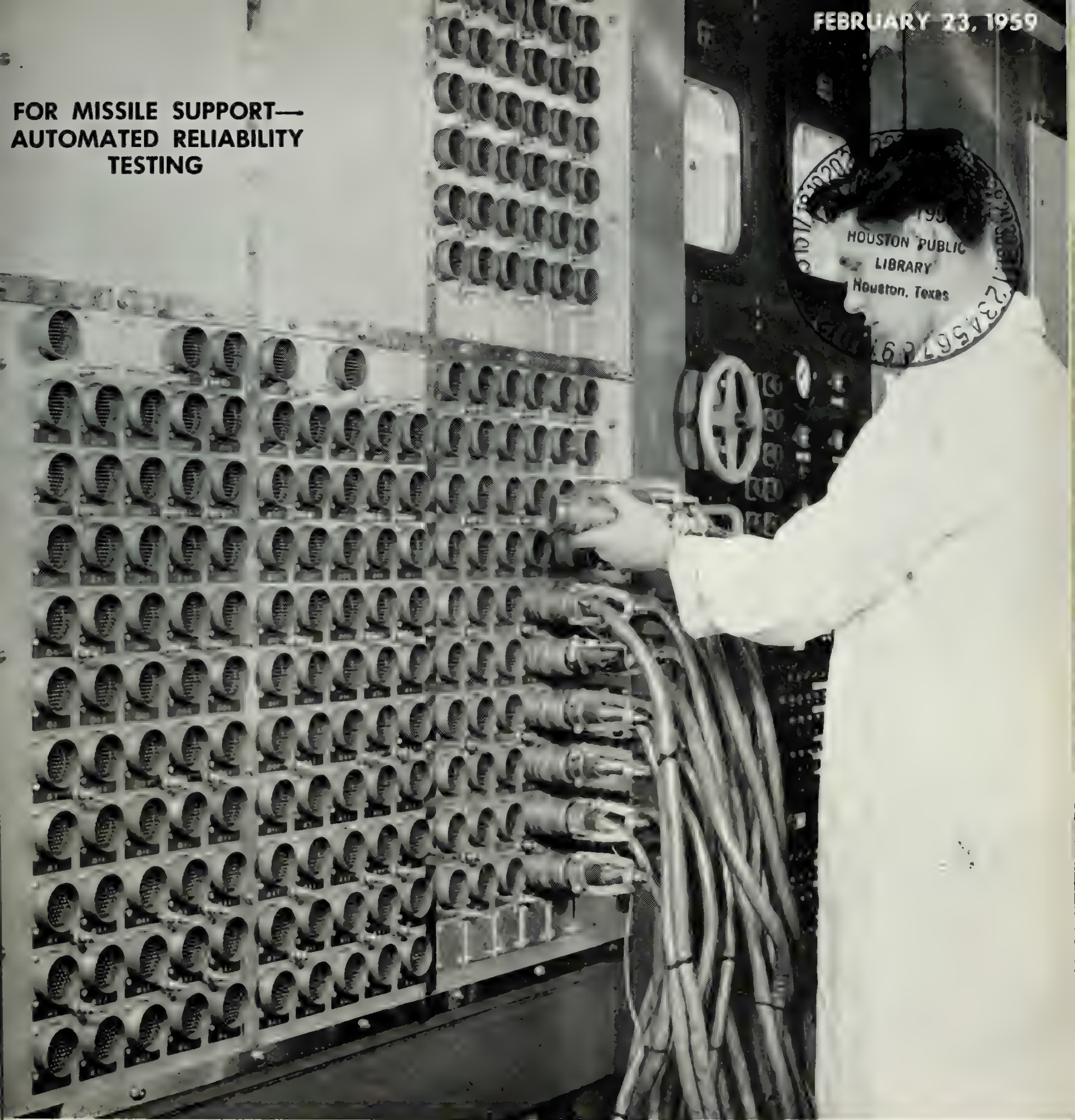
AUTOMATED RELIABILITY
TESTING



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missiles and rockets

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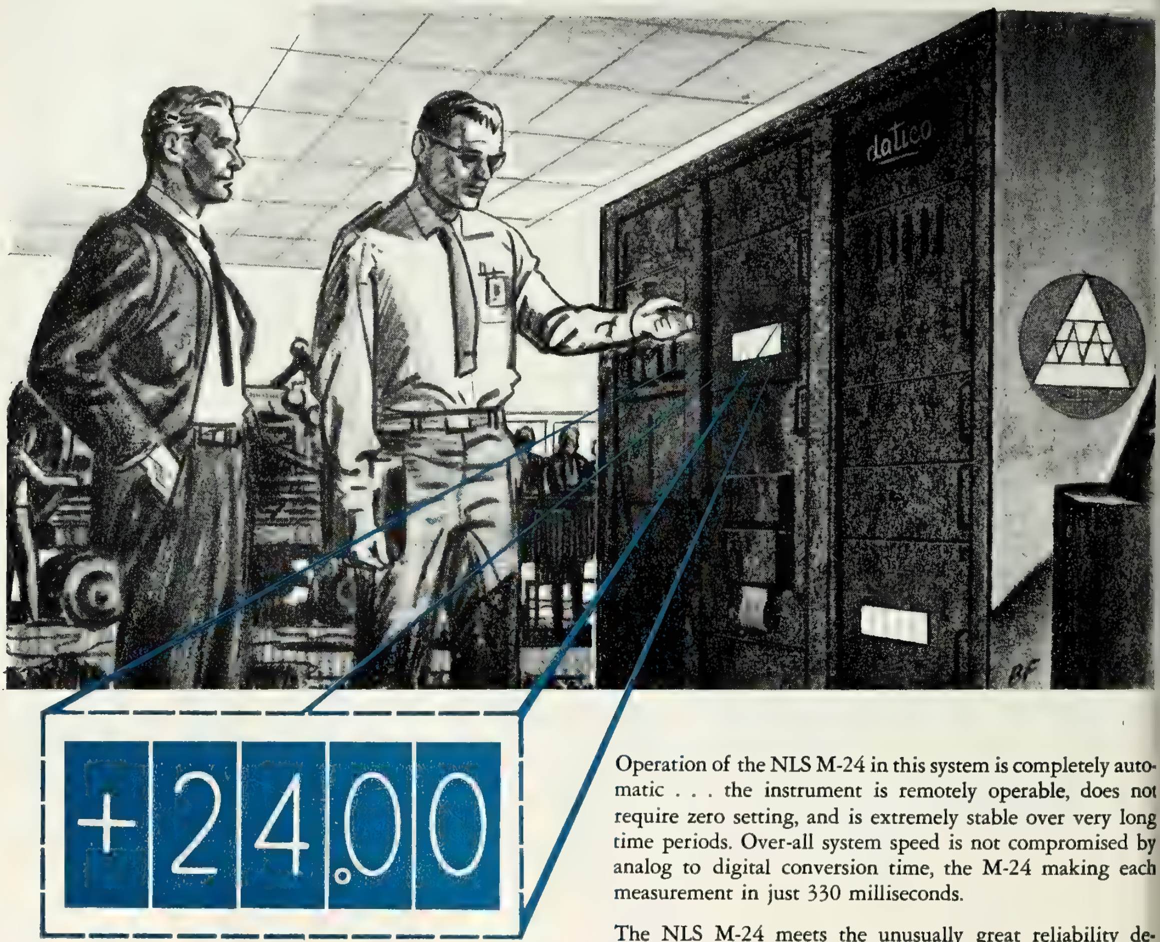
AN AMERICAN AVIATION PUBLICATION

Transistorized NLS M-24 Selected for Missile Checkout System



Analog to digital conversion in Nortronics' Universal Datico is accomplished by the ultra-reliable NLS M-24, the transistorized Digital Volt-Ohmmeter that automatically and accurately measures and displays AC and DC voltages, voltage ratio and resistance.

In Datico, program control is performed by a punched paper tape. Test stimuli are automatically controlled by Datico and output signals (voltage, voltage ratio, and resistance) from the system under test are automatically selected and fed to the NLS M-24. The M-24 digitizes the system outputs to 0.01%, and provides numerical data to the indicator and control chassis for distribution to the data recorder, digital comparator, and visual display on a special NLS in-line readout.

The tape also establishes the go-no-go limits for comparison with the M-24's digital output. It then directs the system to the next channel to be measured.

Operation of the NLS M-24 in this system is completely automatic . . . the instrument is remotely operable, does not require zero setting, and is extremely stable over very long time periods. Over-all system speed is not compromised by analog to digital conversion time, the M-24 making each measurement in just 330 milliseconds.

The NLS M-24 meets the unusually great reliability demanded of automatic test equipment for modern electronic weapons systems. This reliability is assured by transistors, mercury-wetted contact relays (rated at 10 billion measurements), advanced circuit design, and thorough production and field testing.

Proved in the field in a variety of applications, the NLS M-24 Digital Volt-Ohmmeter is in production and ready to go to work for you. Write today for detailed information concerning this outstanding example of NLS leadership in the development and manufacture of digital instruments. A complete catalog of NLS instruments will be sent upon request.

NLS

Originators of the Digital Voltmeter

non-linear systems, inc. DEL MAR (San Diego), CALIFORNIA

NLS—The Digital Voltmeter That Works...And Works...And Works!

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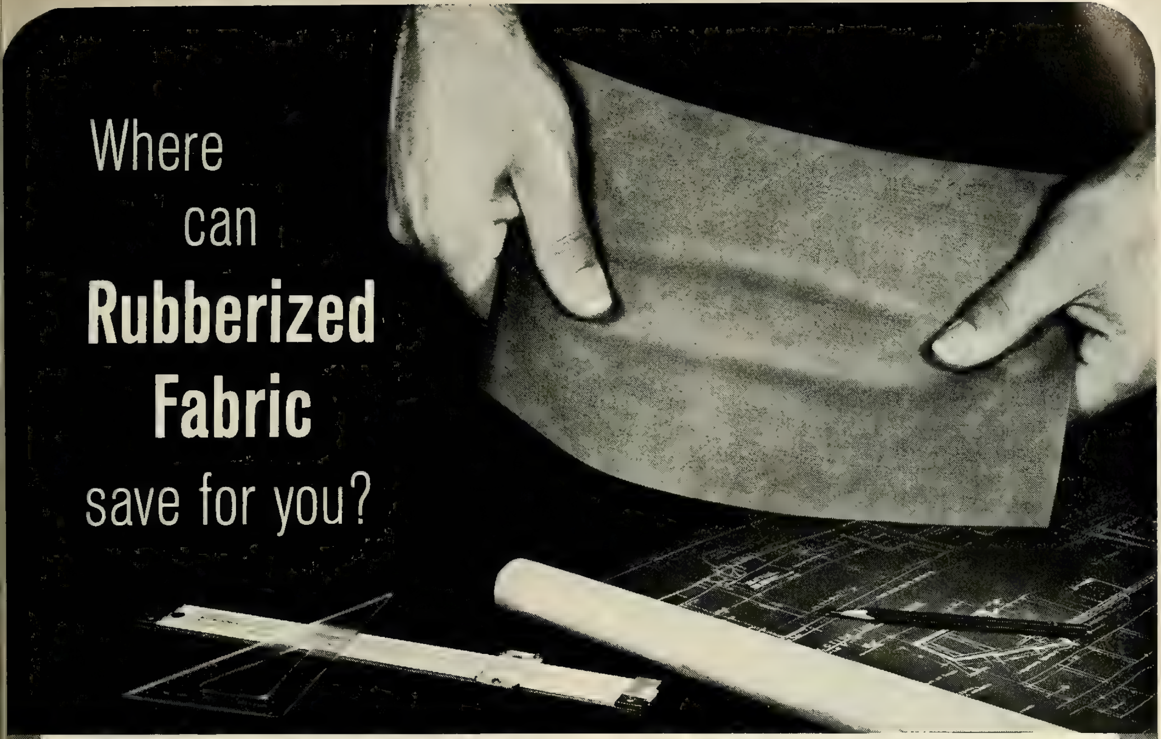
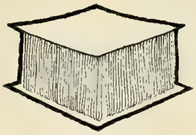
Where can **Rubberized Fabric** save for you?



Need strength, flexibility and portability in one lightweight material? Goodyear Rubberized Fabric may be your answer.

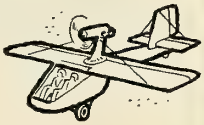
INFLATABLE, PORTABLE

Air Mat Fabric provides excellent insulation against heat, cold, vibration. Ideal for personnel shelters, portable scaffolding, shock cushioning. Beams made of this unique rubber-coated inflatable material have highest strength-to-weight ratio known.



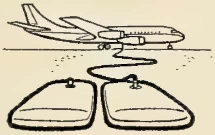
INFLATOPLANE

—another ingenious application of Air Mat Fabric. Pilot simply unfolds it, inflates it—and *flies away!* Do your plans call for a lightweight structural material that can be moved easily, occupies a bare minimum of storage space, can be erected quickly?



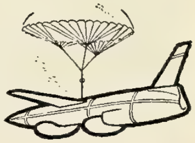
LOOK! COLLAPSIBLE FUEL TANKS

that unroll like a rug—can be set up, filled and pumping 45 minutes after delivery. Eliminates need for bulky, hard-to-handle metal drums. Designed for use wherever temporary or emergency storage of gasoline, oil, water—any bulk liquid—is required.



WANT TO BRING A MISSILE BACK?

Goodyear Recovery Bags—made of tough, rubberized fabric—fold into test missiles, inflate on way down to cushion ground impact. Saves the missile for firing another day, eliminates cost and weight of electronically operated conventional landing gear.



FOR DETAILED INFORMATION on rubberized fabric—and how it can save for you—write Goodyear, Aviation Products Division, Akron 16, Ohio, or Los Angeles 54, California.

AVIATION PRODUCTS BY

GOODYEAR

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Bendix Aviation Corporation will be prime contractor for the Eagle missile—and Bendix Systems Division will quarterback the project.

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Responsible for systems management and engineering in connection with the project, Bendix Systems Division will also direct the development of the Eagle missile, electronic guidance, and fire control equipment in the launching aircraft.

Engineers and scientists with missile experience may find that their talents are suited to the specialized work involved in the Eagle project and other important system programs at Bendix Systems Division.

Located adjacent to the Engineering campus of the University of Michigan, Bendix Systems Division offers the better man an outstanding opportunity to join an organization with full facilities for encouraging his finest work. Ann Arbor is a wonderful place to live and raise a family, a town which combines life in a college community with the nearby advantages of a large city.

If you are interested and qualified in weapons system planning, research and development, you are invited to write to Bendix Systems Division, Dept. K2-23, Ann Arbor, Michigan.

Bendix Systems Division
ANN ARBOR, MICHIGAN

Bendix AVIATION CORPORATION

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missiles and rockets Vol. 5, No. 8, Feb. 23, 195

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missiles and rockets

MAGAZINE OF WORLD ASTRONAUTICS

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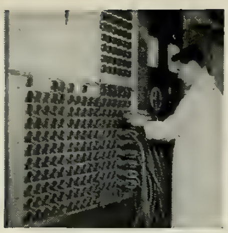
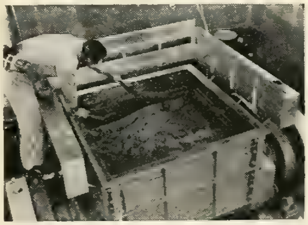


COVER: Cook Electric has 14 test chambers such as this for reliability testing. (p. 24)

LATEST in company team efforts is the *Hilo* drone by Bendix, Republic and Marquardt (p. 21)

NEW "sagging method" was used by Corning in making large telescope mirror. (p. 29)



SOLIDS mixer by Baker Perkins is boosting propellant output for Thiokol Chemical Co. (p. 26)

RECOVERABLE Lockheed *X-7* ramjet test vehicle has made 100 tests with 75% successful.

Test of a warhead developed by Rheem that utilizes a new principle in the state of the art of warhead design. Rheem development is fully supported by test sites, chemical laboratory, ballistics tunnel, and a separate Explosives Loading Facility.

For the past two decades and through two major conflicts, Rheem Ordnance has been *a force to reckon with.* As a major ordnance contractor for our Armed Forces, Rheem produced millions of shells and made significant contributions to ordnance technology in the design, development, and production of fuzes, rockets, practice bombs, land and underwater mines, and other conventional armament.

Today, all branches of the Armed Forces continue to look to Rheem for leadership in Explosive Ordnance, Missile Warheads and Fuzes, and Basic Research. A partial list of current projects underway at Rheem includes:

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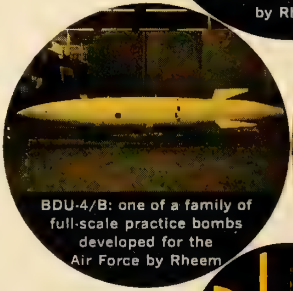
EXPLOSIVE FORMING OF METALS
EXPLOSIVE RESEARCH AND HYPERVELOCITY IMPACT
RELIABILITY AND LETHALITY STUDIES

Rheem Ordnance makes many products that it hopes will never be used. But the ultimate in reliability is carefully engineered into every Rheem product, so that, should an aggressor strike, America's defenses will not be found lacking.

For more complete information on Rheem Ordnance capability, write to Dept. MR-707-1

Newly developed fuze for Nike Hercules warhead—designed, tested and produced by Rheem



BDU-4/B: one of a family of full-scale practice bombs developed for the Air Force by Rheem

Advanced warhead for Hercules: develope tested and produce by Rheem

RHEEM MANUFACTURING COMPANY

Rheem

Defense and Technical Products Division

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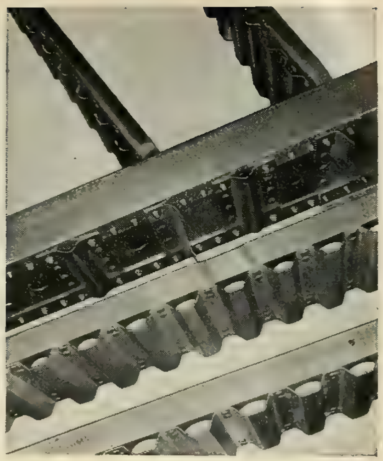

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MANUFACTURED AT
HI-SHEAR INCLUDE
HI-TORQUE BOLTS
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BLIND NUTS AND
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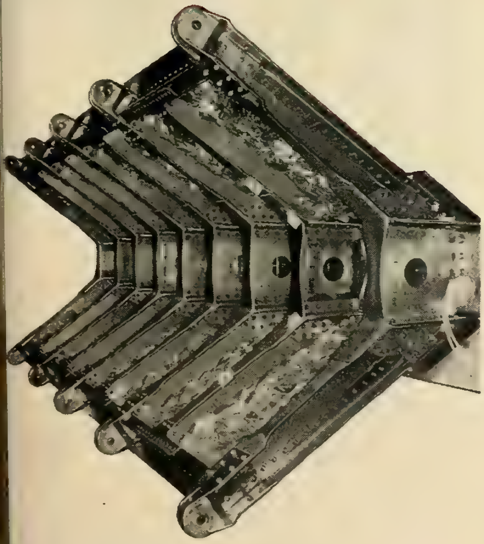
The X-15 research vehicle . . . ready for the first manned probe into space . . . with speeds exceeding 3600 mph . . . for altitudes above 100 miles . . . to withstand 1200°F . . . a challenge for fastening techniques.

The selection of the Hi-Shear rivet for use in the X-15 is an outstanding example of how this and other high strength fasteners are being developed at Hi-Shear research facilities to keep pace with the ever changing requirements of the aircraft and missile industries.

The Hi-Shear rivet *still* offers the *lightest strength-weight ratio* of any swaged type fastener, simplicity of installation and service reliability established by sixteen years acceptance by industry.



VING ATTACH STRUCTURE IS ASSEMBLED WITH INTERFERENCE FIT HI-SHEAR RIVETS. THE HS128 PINS ARE 17-4PH STAINLESS STEEL, HEAT TREATED TO 120,000 PSI MINIMUM SHEAR. THE HS91 AND HS92 PINS ARE A-286 ALLOY, HEAT TREATED TO 95,000 PSI MIN-MUM SHEAR. BOTH PINS USE HS60M R MONEL COLLARS.

Contact your Engineering Standards Group or write to us for specific fastener data.

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HARD

-Based

. . . and safe

When the U.S. Air Force tackles a problem, they are completely realistic; there is no room for wishful thinking.

Thanks to the Air Force's development of *hard-based* missile systems, we have the means to counterattack effectively — *within minutes* — from installations that are virtually invulnerable.

AMF's Greenwich Engineering Division, as the foremost designer-developer of hard-base missile installations, is proud to have helped make the original studies to evaluate these systems, and prouder still of its designs for the Titan and other programs. AMF is the most experienced contractor in the complex and exacting field of hardness engineering.

Missile support specialists will find challenging job opportunities with AMF at several attractive locations — on both coasts!

AMF

AMERICAN MACHINE & FOUNDRY COMPANY
GREENWICH ENGINEERING DIVISION - 11 BRUCE PLACE, GREENWICH, CONN.

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The New Line-up in Space

Defense Secretary Neil H. McElroy took a first step toward clarifying the nation's murky space projects picture when he straightened out some of the lines of authority in his Pentagon infield, although there is still some doubt as to who calls the play—Holaday, Johnson or York.

Before Congress, in a press release and by directive, it was spelled out something like this:

Dr. Herbert York is the boss of Defense Research and Engineering and, for the first time, McElroy seems to have given him some of the authority that Congress unquestionably intended he should have when it passed the law establishing his position. Two very important items in his charter say he is specifically delegated authority to:

"Issue instructions and one-time directive-type memoranda appropriate to carrying out policies approved by the Secretary of Defense for his assigned fields of responsibilities.

"Approve, modify or disapprove programs and projects of the military departments and other Department of Defense agencies in his assigned fields to eliminate unpromising or unnecessarily duplicative programs, and initiate or support promising ones for research and development."

That's a lot of authority if Secretary McElroy really means it and will back York up in getting the money he will need.

Roy Johnson's ARPA is the operating agency to carry out the directions of Dr. York, Congress was told. Here Secretary McElroy made his greatest concession to unified control. Before the Congressional appearance both he and Johnson had been adamant and emphatic that Johnson report to McElroy and McElroy only. Now, in research and development matters he reports to Dr. York. Queried as to the reason, one associate of the office said:

"Some of the people in the Pentagon were getting as tired of the confusion as some of you outside."

William M. Holaday, whose continued presence anywhere in the scientific space business puzzles a great many of his colleagues, remains there nevertheless as Special Assistant to his fellow-Ohioan, Secretary McElroy. Holaday was formerly Director of Guided Missiles. Before that office was absorbed by Dr. York's, he became Chairman of the Military Liaison Committee with the National Aeronautics and Space Administration—a $20,000-a-year position which he still retains.

In his new job, it has been explained, Mr. Holaday additionally will be the production expediter. After Dr. York has decided upon the project and Mr. Johnson has carried forward the research and development, Mr. Holaday will clean up the problems of getting the project into production and hardware. He does not draw two salaries.

This clarification will meet the approval of all of us who want an orderly national program of space development. But there are other clouded areas which can be accepted only on faith.

For instance, the other day ARPA's Roy Johnson startled even his own staff members by declaring in a conference called to discuss the power plant for a new space project that ARPA could do nothing about it (ARPA is the sole agency managing military space projects) because in the future NASA will develop all space engines. This, he said, was an agreement he had made with Dr. T. Keith Glennan, head of NASA.

Now that the implications of this startling fact have finally filtered through to the military services, emotions are mixed. For in final delineation it means that a civilian agency will be writing the specifications for the engines around which the services must build military space machines. This concept of separate design for the component parts of a weapon system had long ago been abandoned, if it ever was really accepted. The engine and the machine now have a loving courtship, not a shotgun marriage.

It takes a lot of faith indeed to accept this situation. With NASA it may work (although one wonders if this test of faith is really necessary) because NASA is built on the old foundation of the NACA—an organization which for years worked in the closest harmony with the military. It will be a sad thing if that same cooperation does not continue, that is, if NASA does not utilize military skills and does not make military needs a prime requisite in any powerplant project.

Peaceful space exploration is both good and important, but we would like to point out again that unless the free world's military can guarantee our unmolested presence there we won't be doing any exploring in space, peaceful or otherwise.

CLARKE NEWLON

fast-maturing TI infrared systems advance IR early warning, reconnaissance, tail-warning...

ALL-OUT DEVELOPMENT of the precocious infrared sciences at Texas Instruments has brought this versatile field to new levels of sophistication — a maturity that spells design simplicity in complex systems, and permits expert use by inexperienced personnel. The keys to this new status for infrared are *new optical materials, new materials/systems/application matching techniques, advanced detector cells,* and *low-noise transistorized circuitry* — all pioneered by Texas Instruments.

This experience can work for you immediately, whether your particular interest is reconnaissance, distant detection, early warning, tracking, tail-warning, or merely curbing a heat-seeking missile's tendency to chase the sun. To obtain IR technical services, backed up by the capacity to produce in any quantity the systems you require, properly cleared military or industrial personnel contact SERVICE ENGINEERING DEPARTMENT:

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apparatus division

systems management

systems — airborne early warning, airways control, antisubmarine warfare, attack-bomb navigation systems, countermeasures, engine instrumentation, missile systems, portable ground equipment, reconnaissance, space electronics.

equipments — radar, infrared, sonar, magnetic detection, computers, timers, telemetering, intercom, microwave, optics, detector cells, engine instruments, transformers, time standards, and other precision devices.

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STEPS IN THE RACE TO OUTER SPACE

Assembling a station in space

This imaginative but technically accurate illustration shows a permanent satellite (center) being constructed in orbit around the earth. It generates its own heat and electricity from solar rays. Basic vegetation (such as algae) for oxygen as well as protein-rich foods are rown in hydroponic tubes in upper evel "greenhouses."

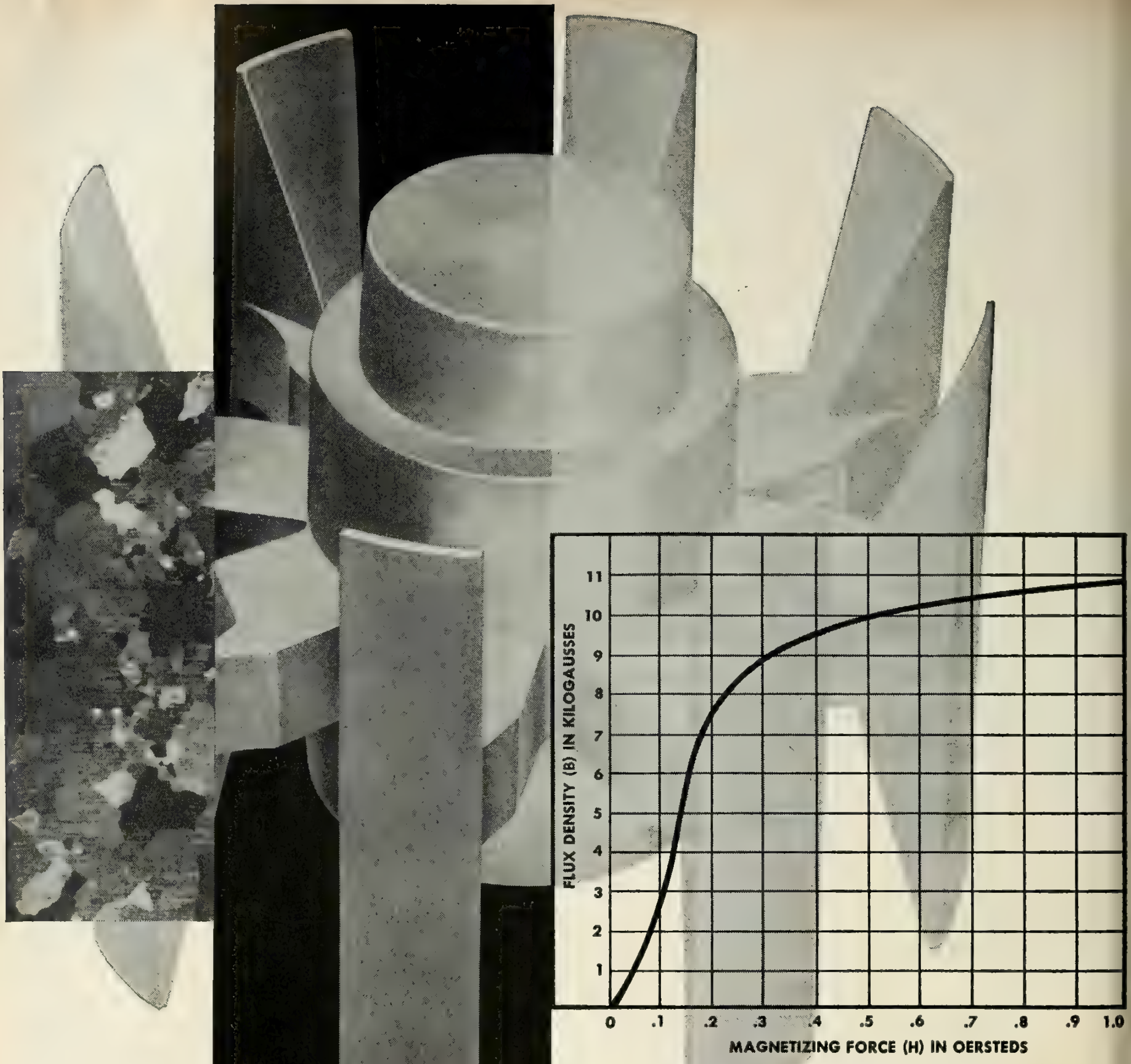
New vistas in astronomy will be pened up by such a space station, ecause of perfect conditions for hotography and spectroscopy. It will lso provide unique conditions for advanced research in physics, electronics, weather prediction, etc. Three such stations, properly placed, could blanket the entire world with nearly perfect TV transmission.

Atomic rocket vehicles with prefabricated skin layers (lower center) provide building materials for the station, then return (bottom) to earth. Similar craft will service an established station (lower right), docking by electromagnetic pull in lower section of station's axis.

ENGINEERS • SCIENTISTS

ARMA needs key men to augment a broad research program in missile guidance and space technology. As designer and developer of all-inertial navigation systems for TITAN and ATLAS ICBM's, **ARMA** provides a stimulating atmosphere where creative talents can develop. Write to E. C. Lester, Professional Placement, MR-2 **ARMA** Division, Garden City, N.Y. A Division of American Bosch Arma Corporation.

AMERICAN BOSCH ARMA CORPORATION



B-H curve for average precision cast Hipernik.

Investment casting eliminates costly machining of this Hipernik magnetic alloy hysteresis clutch.

Westinghouse Hipernik Casting

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The field of electronics has created special metal problems. The Westinghouse Metals Plant has accepted and solved some of these problems.

Cast Hipernik® is particularly adaptable to the requirements of missile control systems. Other applications in the electronic control and instrumentation fields are transformer cores, pole pieces, solenoids, torque motors, magnetic clutches and many special magnetic applications.

The Westinghouse Metals Plant may be able to cut your costs by eliminating unnecessary machining, yet delivering to you a completely finished component ready for assembly. This modern metals plant can furnish strip, sheet and bar stock in other magnetic and high temperature alloys. Write to: Westinghouse Metals Plant, Blairsville, Pennsylvania. Our latest bulletin on Hipernik will be sent to you by return mail. J-05005

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washington countdown

There is now little hope . . . of increased funding for *Nike-Zeus*. Dr. Herbert York told the House Space Committee that progress thus far was insufficient to warrant any "confidence" as to its operational capability. Present budget provides about $300 million for accelerated research, development and test. However, no money is provided for production because, as Dr. York explains it, production at this time would get in the way of development. Army viewpoint is that *Zeus* is ready for production even though some modification and retro-fitting would be required later.

Chances are good . . . that ARPA director Roy Johnson will buy a substantial part, if not all, of a proposal by Maj. Gen. John Medaris and Dr. Wernher von Braun for funding of Project *Saturn*. The proposal calls for building (probably at Redstone) 16 vehicles including the 1.5 meg rocket cluster and a second stage, and construction of launch pads at Cape Canaveral. Johnson approved the funding of the launch pads in two increments, out of fiscal 1959 and fiscal 1960 funds, for a total of about $83 million. He has expressed some doubts as to the need for 16 vehicles but has given his blessing so far for four vehicles which may be upped to a minimum of eight.

Recruiting of scientists . . . for missile and space programs as well as for weapon system evaluation by the Institute for Defense Analyses, IDA will be investigated by the House Military Operations Subcommittee. Inquiry is scheduled to start about March 2. For contrast, the subcommittee will ask Vice Adm. Hyman G. Rickover how he put the organization together which successfully produced the Nautilus.

A 10% increase . . . in missile expenditures is forecast by chairman George H. Mahon (D-Tex.) of the House Military Appropriations Subcommittee. The $700 million would be used to step up construction of *Atlas* ICBM's.

Woomera rocket range . . . is being extended for tests of ballistic missiles. Prototype *Black Knight* has been tested and preparations for testing the long-range *Blue Streak* are well advanced.

U.S. Navy reportedly . . . is dickering with Australia for an instrumentation facility for use by PMR on Manus Island. Negotiations also are going on between U.S. and Great Britain for another site in the Christmas Islands.

Royal Navy has decided . . . to adopt a short-range surface-to-air missile developed by Short Brothers and Harland known as the *Seacat*. Powered by a solid-fuel motor, it was developed from the *SX-A5* research vehicle. Another version—*Tigercat*—is being designed for use by ground forces.

AF has high hopes . . . of getting substantial funding from Congress for its long-planned multi-purpose rocket test vehicle, *WS609A*, assigned to BMD. The four-stage solid rocket would be used for scientific payloads in excess of 50 pounds. AF Research centers needing space environmental data for such projects as *Dyna-Soar* and manned orbiting capsules could send up instrumentation without having to wait for miniaturization of instrument components. NASA has a companion all-purpose rocket vehicle in the works termed Project *Scout*.

Negotiations for *Sidewinder* . . . purchases have been completed by the Royal Swedish Air Force. The U.S. Navy-developed *Sidewinder* in "considerable numbers" will become standard armament in Sweden's J-32B Lance, J-35 Hawker Hunter, and the J-35 Dragon.

Quality control . . . program policies of DOD have been strengthened in a new directive, 4155.10, which is expected to promote better quality and reliability.

B.F.Goodrich

B. F. Goodrich Unilock Rivnuts designed especially for aircraft and missiles

New lightweight steel Rivnuts with thread-locking feature preserve structural strength...save assembly time and costs

Ordinary anchor type fasteners used in aircraft and missiles require as many as three holes. And installation is made by two men who must have access to both sides of the work.

But new B. F. Goodrich Unilock Rivnuts can be installed by *one* man from *one* side of the work. Only one hole is needed. And the job can be done at any time during or after assembly.

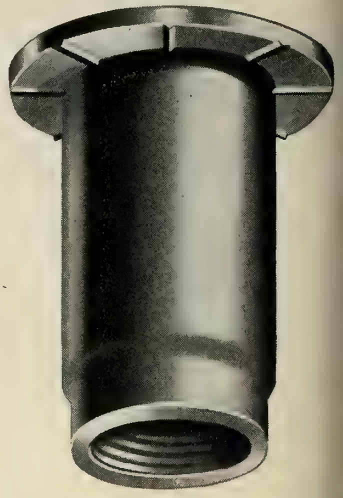
This greater flexibility in manufacturing procedure means a substantial savings in cost. In addition, with only one hole required instead of three, greater structural strength is maintained.

B.F.Goodrich Unilock Rivnuts, in fact, actually reinforce holes. That's because the equally spaced V-teeth under the Rivnut heads lock the Rivnuts to the material in which they are installed. This eliminates the need for a key and keyway—elements which ordinarily set up points of stress concentration.

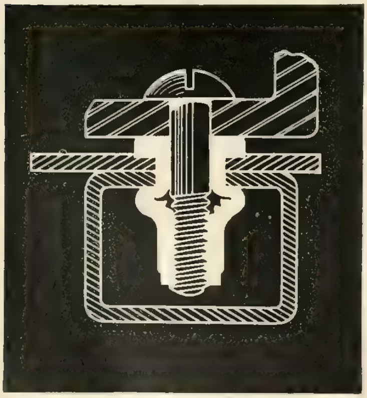
The thread-locking feature is a short crimp in the shank of B. F. Goodrich Unilock Rivnuts. This provides attaching screws with an all-metal interference fit that locks them securely in place.

Made from aircraft quality alloy steel, B. F. Goodrich Unilock Rivnuts are actually lighter than most anchor type fasteners. Yet they will meet strength and torque requirements of Military specification MIL-N-25027 for lock-type nuts.

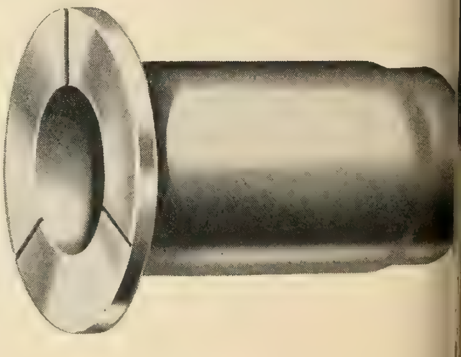
B. F. Goodrich engineers will be happy to make recommendations concerning the use of Unilock Rivnuts in your products. For complete information write *B. F. Goodrich Aviation Products, a division of The B. F. Goodrich Company, Dept. MR-29, Akron, Ohio.*



B. F. Goodrich Unilock Rivnuts are basically the same in appearance and function as regular type Rivnuts. However, the Unilock design is identified by the V-teeth under the head and the crimped shank end which provides the thread-locking feature. Radial marks on top of the head readily indicate grip range.

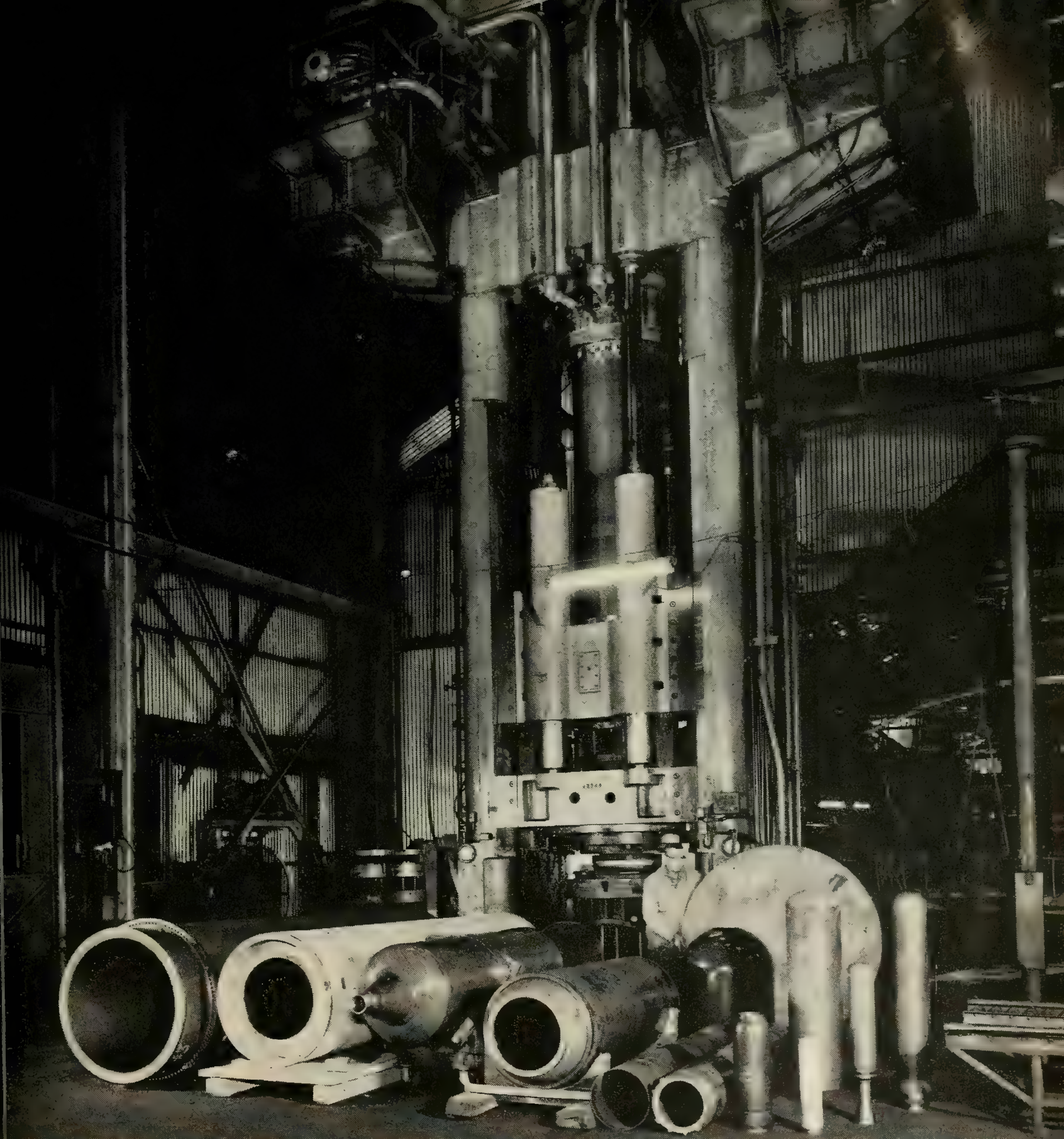


Typical Unilock Rivnut installation in blind application. Installation principle is same as for regular Rivnuts.



Equally spaced V-teeth, made as an integral part of the under side of the head, engage with surface of material in which the Rivnut is installed, thus providing high torque resistance and eliminating need for keyed head and slot.

B.F.Goodrich ***aviation products***



CAPABILITY - MISSILE MOTOR CASES

Scaife's role in the missile field is best illustrated by the 10 missile items pictured above. These items range from 4½ inches to 45 inches in diameter and from 18 inches to 180 inches in length, and were manufactured by utilizing the fabricated and deep-drawn methods of construction for both R & D and Production programs. Presses such as the 1500 ton triple action hydraulic press with 188 inches of stroke, shown in the background, together with the missile metal parts "know-how" acquired over nearly a decade, are available for application to your missile programs. For further information write today, or telephone EMerson 2-2100.

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130,000 pounds of liquid oxygen can be stored and transferred by this giant liquid gas container. The vacuum jacketed tank holds liquid at −297.4°F with negligible losses. Designed and built by Cambridge Corporation, Lowell, Massachusetts, for Douglas Aircraft, the tank is used in fueling the Air Force Thor Ballistic Missile.

World's Largest Airborne Dewar, example of . . .

Improved Low Temperature Liquid Handling

WITH CAMBRIDGE CRYOGENIC SUPPORT

Cambridge Corporation offers the aviation and missile industry a unique single source of technical service and equipment for all types of low temperature liquid handling.

The liquid oxygen Dewar shown above is one example of this facility. Cambridge designs and builds a complete line of liquid gas storage vessels, truck transports, semi-trailers, and pumps for oxygen, nitrogen, argon, hydrogen and other cryogenic fluids.

New materials and techniques offer lighter weight and maximum dependability.

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industry countdown

Pershing vertical launch . . .

facility at Cape Canaveral is underway with site clearing by Jacksonville District, Corps of Engineers. Facility will have a blockhouse, two launch pads, a nose installation building, and a mobile service structure servicing either pad. *Pershing* is being fabricated at Martin-Orlando. Firing team will be composed of ABMA personnel and Martin representatives.

Northrop has acquired . . .

Page Communications Engineers, Inc. of Washington through an exchange of stock. The deal reportedly cost $3,200,000 and is part of Northrop's expansion into the new field of advanced systems for long-range radio communications.

Total infrared volume . . .

in early 1960's—both industrial and military—will be more than $500 million. That's the estimate of Henry Blackstone, president of Servo Corp. DOD's Project *Midas*—detection of the heat of ICBM's over long distance by infrared—will figure heavily in funds for infrared R&D. Pentagon infrared research expenditures for Fiscal Year 1960 will be more than $100 million.

Some 67% of voting stock . . .

of Cribben & Sexton Co., Chicago appliance company, has been acquired by Waste King Corp., Los Angeles producer of missile components.

Multi-billion-dollar project . . .

is how some AF officials describe a long-term program to expand the service's space-age communication requirements. AF has announced as a first step that International Telephone & Telegraph Co. and Radio Corp. of America will be awarded a $3 million contract to assist in figuring out AF total communication needs through 1970 and beyond. Ultimately, RCA and ITT would be the service's manager and technical director. The two companies have indicated that Hughes Aircraft Co. and Hoffman Electronics Corp. would serve as contractors. The project is known as 380L.

Sylvania merger into . . .

General Telephone Corp. should permit greater diversification of investment and increased R&D for General Telephone, plus an improved position for Sylvania to diversify and finance its future development. The merger—approved by directors of the two companies last November—will become effective about March 5. It has been predicted that the combined company will show operating revenues of over $1 billion in 1959.

First all-ceramic radome . . .

made on a production basis will be manufactured by Gladding, McBean & Co. of Los Angeles for *Sparrow III*. Radomes to be produced for Raytheon will be fabricated from high-purity ceramic oxides. The alumina radome's dielectric constant is 8.82 at 77°F and 9.73 at 1472°F. Its dissipation factor is .00022 at 77°F and .0015 at 1472°F. It reportedly can withstand temperatures up to 3000°F, and has flexural strengths exceeding 45,000 psi.

$1,356,290,000 military building . . .

authorization request has been made to Congress. Army wants $231,252,000; Navy, $195,284,000, and AF, $872,761,000.

27¢ of the procurement dollar . . .

in FY 1960 will go for missiles, Assistant DOD Secretary Wilfred J. McNeil has told Congress. Purchases for aircraft will dip to 45¢ of the dollar. In FY 1957, aircraft took 58¢ and missiles got 15¢.

Planned Army obligations . . .

through FY 1960 for missiles, looks like this: *Nike-Ajax,* $1,257,400,000; *Nike-Hercules,* $1,882,800,000; *Nike-Zeus,* $591.5 million; *Redstone,* $513.2 million; *Sergeant,* $257.5 million; *Corporal,* $286.3 million; *Lacrosse,* $270.9 million; *Honest John,* $250.5 million; *Little John,* $60.5 million.

Rare, tough and rough rhenium . . .

is being commercially produced by Chase Brass & Copper Co. of N.Y. Fabricated forms include rod, wire and strip. Chase says that tests using rhenium for electrical contacts have shown a life expectancy 30 times greater than that of any material currently being used.

Hughes in Southern California

announces the establishment of

a major new division . . .

the COMMUNICATIONS DIVISION

The growing importance of global and space communications, together with major contributions of the Hughes Communications Laboratory, such as the Long Arm and Quicksilver programs, has resulted in the creation of the COMMUNICATIONS DIVISION of the Hughes Aircraft Company. The new division is fully integrated and will be responsible for communications research, development, manufacturing and sales. Expansion plans are ambitious and aggressive, and the backlog of contracts already awarded promises an expansion consistent with the spectacular records established by the other major divisions of Hughes Aircraft Company.

The establishment of Hughes as a major factor in the communications industry has created many openings for experienced electronic engineers i the following areas:

Senior Staff Engineers
RF Power Design
Digital Data Processing
Transistor Circuit Design
Communication Systems Analysis
Propagation Specialists
Upper Atmosphere Physicists

also

Airborne Equipment Productizing Engineers
Test Engineers

For further information write Mr. John Melville at the address below.

HUGHES

COMMUNICATIONS DIVISION, P. O. Box 90-902, Los Angeles

Now...because of new

and expanded product lines,

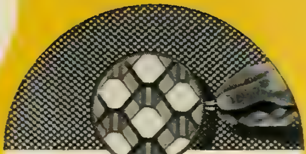
Swedlow Plastics Company

announces a change in name to...

SWEDLOW Inc.

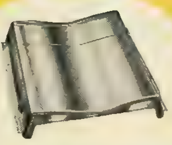
(EFFECTIVE FEBRUARY 1, 1959)

RETCHED AND MONOLITHIC LASTIC GLAZING for aircraft windows and enclosures. Optically polished, tough, light weight.



HIGH TEMPERATURE WELDED AND ALUMINUM HONEYCOMB CORE. For aircraft and missiles. Heat resistant, light strong.

GOLD AND ALUMINUM METALIZED PLASTIC LAMINATES. Minimum weight, minimum bulk, heat protection to 1650° F.



HIGH TEMPERATURE REINFORCED PLASTIC LAMINATES for sheeting and contoured parts in missiles and aircraft.

PRIMARY SOURCE FOR CONTINUOUS AND PRESS MADE LAMINATES for aircraft and industrial uses—fibre glass, cotton, nylon, etc.

KEVINITE FLEXIBLE, DECORATIVE LAMINATE. An all-paper, polyester, continuous laminate, available in many color and design combinations.

Swedlow has long been well known as a leader in the development and fabrication of high quality Plastic Glazing for aircraft. Excellence in this field has resulted in demands for the same type of development and craftsmanship in additional products of fine quality, involving metals and many other materials.

High temperature Welded Honeycomb Core in stainless steel and super alloys has become a very important part of our business, along with Aluminum Honeycomb Core, and the volume of these light weight, strong structural materials is growing rapidly to meet the increasing needs of aircraft, missile and other industries.

Swedlow products also include a wide variety of high heat-resistant reinforced plastics, utilizing fibre glass with silicone, phenolic and epoxy binders and metalized for extra heat protection.

This diversification and expansion makes the change to a more inclusive name desirable. In all of its products, the company will continue to adhere to the highest standards of quality and workmanship in the future.

SWEDLOW Inc.

LOS ANGELES 22, CALIFORNIA / YOUNGSTOWN 9, OHIO

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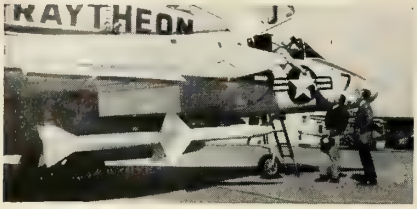
Raytheon Missile Projects



SPARROW III—the Navy's tenacious, lightning-fast, air-to-air missile—is intended for extensive use by Navy fighter aircraft in fleet air defense. Sparrow III is a Raytheon prime contract.

HAWK—the Army's defense against low-altitude attackers—carries out its destruction in the blind zone of conventional radars. Hawk development and production is under Raytheon prime contract.

TARTAR—A substantial contract for vital electronic controls for this Navy destroyer-launched missile is held by Raytheon. This equipment—a tracking radar and associated units—enables it to "lock on", cling to target's path, despite evasive tactics.

ADVANCED PROJECTS in aeronautical structures as well as missile guidance and control are now underway in Raytheon laboratories. New facilities are continually being added for this work.

PRELIMINARY NEW DESIGNS of tomorrow's missiles will result from the advanced work being done by today's missile engineers. Raytheon plays an important role in this area.

Raytheon diversification offers

JOB STABILITY FOR CREATIVE MISSILEMEN

Here is an opportunity to free yourself of worry about a job that's here today, gone tomorrow.

Diversified assignments—only possible in a company with Raytheon's wide range of missile activities—means security not found in one- or two-project companies. You apply your creative energies to the many projects you work on, and they in turn are your "insurance" against falling into a rut.

Individual recognition comes quickly from Raytheon's young, engineer-management—men who are keenly aware of the engineer's needs and contributions to missile progress.

Dynamic Raytheon growth—the fruit of this management's progressive policies—is best illustrated by the fact that Raytheon is already the only electronics company with two prime missile contracts—Navy Sparrow III and Army Hawk.

The next step is up to you. Why not get frank answers and helpful information on the type of job suited to your background and talents, its location, salary and other important details. Write, wire or telephone collect: The number is CRestview 4-7100 in Bedford, Massachusetts. Please ask **for W. F. O'Melia.**

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RAYTHEON *MISSILE SYSTEMS DIVISION*

Excellence in Electronics

FEBRUARY 23, 1959—VOL. 5, NO. 8
missiles and rockets
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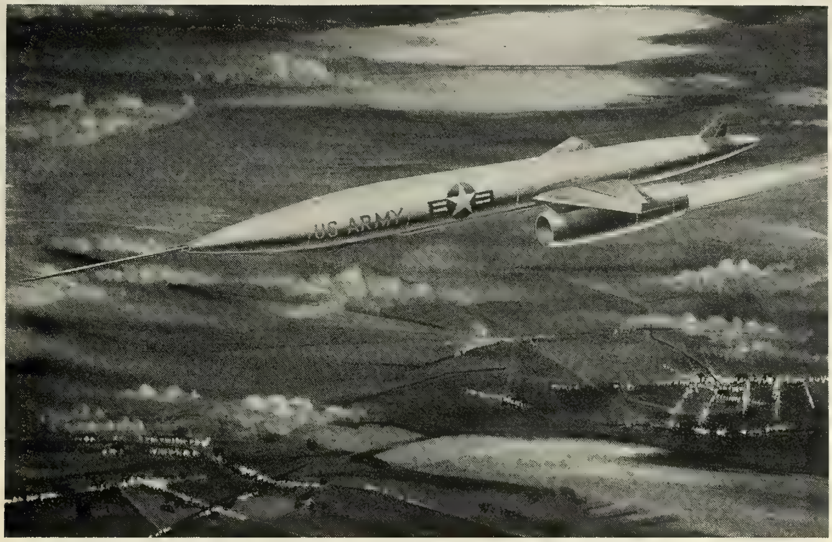


GROUND-LAUNCHED *Hilo* **hits transonic or supersonic speeds at high or low altitudes.**

Four Companies Producing Versatile Drones

Bendix, Republic and Marquardt joined forces in designing ground-launched *Hilo*, providing a bomber-like radar image. Bell worked with Bendix in developing *Penny*, air-launched to perform at high altitude and supersonic speeds.

by Frank G. McGuire

WASHINGTON—Two new drone systems which apparently can handle any requirements set down for them, have been produced largely through the efforts of four companies—Bendix Aviation, Republic Aviation, Bell Aircraft and Marquardt Aircraft. The new systems are *Hilo* and *Penny*.

Details of the drones were discussed in Paris last week at an engineering conference sponsored by Bendix and attended by 800 European engineers and aviation officials.

• ***Hilo* described**—Republic Aviation and Marquardt worked with Bendix in developing *Hilo*, a ground-launched drone for operation at any altitude, and at transonic or supersonic speeds. The target features a single basic airframe unit and a ramjet powerplant for either transonic low-altitude operation or supersonic high-altitude operation. Standard off-the-shelf boosters are used to attain speeds where the 14-inch Marquardt ramjet takes over.

The basic aerodynamic design for use at low altitudes has a high fineness ratio and Hauck nose. Movable mid-wing panels provide longitudinal and roll control, as well as lift, while the vertical stabilizer remains fixed.

For high-altitude operation, fixed wing panels are added to the basic configuration to provide necessary wing area for efficient cruise. Movable panels then act as inboard trailing-edge elevons for the high-altitude wing.

Hilo is 21½ feet long, has a span of 38 inches, and a diameter of 14 inches. Its gross weight with full tanks is 778 lbs. and its empty weight is 472 lbs. It uses radar augmentation to provide an image resembling a large bomber.

• **Low-cost lens**—The Bendix lens used in the radar augmentation system is a small spherical plastic device providing both monostatic and bistatic enhancement. Where applicable, it is lower in cost than active devices, according to Bendix, and is smaller than devices used in passive techniques, such as corner reflectors. In *Hilo*, the scorer, radar altimeter and beacons are located directly behind the lens.

A fiberglass skin is used in the airframe, and two propellant tanks are integral with the fuselage. Fuel flow is achieved through pressure from a fiberglass nitrogen pressure tank.

Command receivers and recovery parachutes are located in the tail of the vehicle. Wings and fins are made of solid magnesium die castings. All parts of *Hilo* are designed for quick assembly.

The guidance and control subsystem includes electric servos, a vertical gyro, a pitch program, a barometric sensor and a radar altimeter. It also uses a beacon to assist ground tracking and a receiver and decoder to accept control commands from the ground.

The *Hilo* target system, states Bendix, is completely mobile, and its equipment is adaptable to most military vehicles. The system uses two vehicles: a transport van carrying four assembled targets, and a launcher mounted on a trailer bed. Fueling is accomplished with the missile on the launcher.

• *Penny* savings—*Penny*, a target drone system developed jointly by Bendix and Bell Aircraft, is described as "a high-altitude, supersonic drone designed specifically as a low-cost expendable target." It is an air-launched vehicle which any type of aircraft can carry. It achieves a good supersonic flight duration with its dual-chamber liquid rocket engine.

The drone's aerodynamic configuration embodies no moving control surfaces. The basic design features a high fineness ratio with small canard surfaces forward, a fixed wing aft and fixed vertical fins.

Penny is about 20 feet long and 13 inches in diameter, and has a total wing span of 64 inches. Gross weight with fuel is 950 lbs. and burnout weight is 438 lbs. Flight is pre-programed into the guidance system.

Pitch control is governed by swiveling one of the two rocket engine exhaust chambers, and lateral control is achieved by a combination of this exhaust-chamber-swiveling and roll jets mounted on the wings.

• **Advantages of simplicity**—The drone's airframe is built of seven sections which make the most of simple production, assembly and maintenance advantages. The forward section is reinforced plastic which doubles as a radome for the radar augmentation and scoring devices. Integral metal fuel tanks are used in the fuselage.

The main wing and tail surfaces are fabricated from magnesium die castings for minimum weight and cost. The after portion of the body is an aluminum shell containing guidance and control equipment. The rocket engines are housed in a reinforced plastic boat-tail.

Penny's guidance and control equipment is comprised of two primary sensors: a two-axis gyro and a pressure altimeter. A variety of mission profiles may be selected through use of a simple programer, which may also be used to destroy the drone at the end of the flight. Both active and passive subsystems are incorporated into *Penny* for radar augmentation, so that the bird may simulate a much larger aircraft. It uses the same type of system as *Hilo*, and an alternate infrared augmentation flare which may be adjusted for varying amounts of radiation.

Penny's electrical system includes a battery, transistorized inverter power pack and molded electrical harness connectors.

• **Bendix roles**—Most of Bendix's 25 operating divisions are in the missile field. Bendix Products Division is prime contractor for the *Talos* SAM. The Pacific Division and the Research Laboratories Division developed the guidance for *Sparrow II*. The Eclipse-Pioneer Division has guidance responsibility for *Pershing*. The Radio Division produces *Talos* guidance equipment and the radar units for missile and fighter control.

Other Bendix Divisions are working on computers, hydraulic systems, electrical systems, auxiliary power units and other components. Bendix is sharing with Grumman in the new AAM *Eagle*.

Industry Briefs

Additional contracts totalling $2,100,000 for *Falcon* components have been received by Crosley Division, Avco Manufacturing Co. Work—which possibly will embrace stabilizers, flippers and other components—will be done in Richmond, Ind.

First of B52G missile platform bombers has been delivered to Travis AFB from Boeing's Wichita plant.

New project name for ARPA-Rocketdyne 1.3-million-lb. booster is Project *Saturn*.

Study contract for space vehicle terminal guidance methods has been awarded to International Telephone and Telegraph Corp. by ARDC. Astronics Lab of ITT in Fort Wayne, Ind., will do the research aimed at defining guidance systems, techniques and designs.

Range Systems Division has been formed by Chance Vought. It will design, develop, install, operate and maintain facilities and personnel for testing and evaluating missiles and space vehicles.

New major data center by Data-Control Systems, Danbury, Conn., has been delivered to ABMA for checking out telemetry links from missiles and satellites.

More *Hawk* ground support equipment and frame will be provided by Nortronics, which received a $16,690,000 subcontract from Raytheon. Delivery will be through 1960. GSE includes mobile launchers, self-propelled loaders and loader attachments.

Air Force will open its 35,000-foot captive missile test track Feb. 25 at AFMDC, Holloman. The track will be used for testing warheads, missile guidance systems, flutter testing air foil sections and human tolerance programs. Original track constructed in 1949 was 3,500 feet.

Proximity scorer device which should save high-priced targets and missiles is under test at Eglin AFB. Mounted in either towed or free-flying targets, the 8½ pound scoring unit surrounds the target with electro-magnetic radiations. When the missile passes near the target, the reflected radiations trigger a relay that transmits miss-distance to the launch aircraft, target aircraft, or ground observers.

Antisub Division set up by Aerojet-General shows new management trend in the expanding anti-submarine warfare field. Aerojet has multi-million-dollar contract for development and production of an antisub torpedo.

Vanguard II Big Step in Weather Reconnaissance

WASHINGTON—The first step toward a continuous satellite weather mapping system was accomplished last week with the successful launch of *Vanguard II*, a 21½ pound sphere containing two photocells which scan the clouds, sea and earth below.

Early computations placed the satellite's perigee at 335 miles and apogee at 2050 miles. The satellite's orbital period is 126 minutes and its inclination to the Equator is 34 degrees.

Indications are that the satellite will remain in orbit indefinitely.

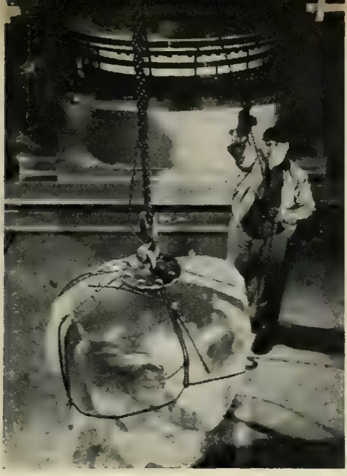
The photocells are mounted behind circular, gridded windows which project from the satellite. Their reflections from the cloud, sea and land masses below will be translated into electrical impulses and then telemetered by tape recorder to ground stations.

One transmission will be sent on each of the satellite's orbits at command of the ground station.

Expected life of the cloud cover instrumentation (operating at 108.03 megacycles) is two weeks. The Minitrack transmitter (operating at 108.00 megacycles) is expected to last four weeks.

Life of the weather transmitter's mercury batteries was lengthened by tucking solar cells behind the two windows, which turn on the cloud-spotting cells only when the satellite is over sunlight portions of the earth.

The satellite should reveal cloud data over about 25% of the earth's sunlit surface in 600-mile-wide strips.



Giant Mirror Created for NSF's New Observatory

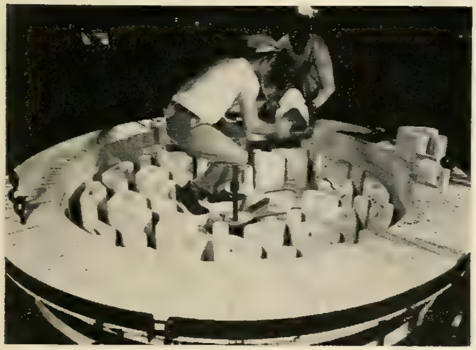
Corning's reflector, largest built in 25 years, was made by 'sagging' and must cool for seven months.

by Donald E. Perry

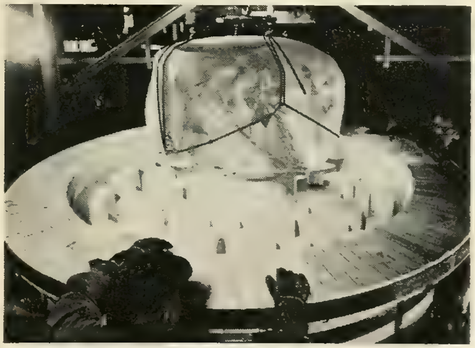
CORNING, N.Y.—The heat treatment is over. Another giant eye for probing the universe is cooling—ever so slowly—as if in tribute to the six months of planning and engineering which went into its production.

This summer, Corning Glass Work's newest contribution—the largest glass telescope mirror blank since completion 25 years ago of the 200-inch disk for the Hale Observatory—will be shipped to Tucson. There the disk will be ground and polished and gently hauled to a 6875-foot mountain peak, site of another observatory to be constructed by the National Science Foundation.

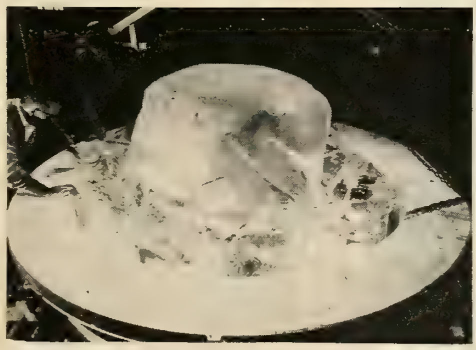
This giant reflective piece has an 84-inch-diameter disk and weighs over 3500 pounds. Some 13 inches thick and with a 26-inch center hold diameter, it demanded a new process from skilled glass artisans, vital backbone of the missile-space industry. Outcome has been a new process—termed "sagging"—which is told pictorially by m/r.



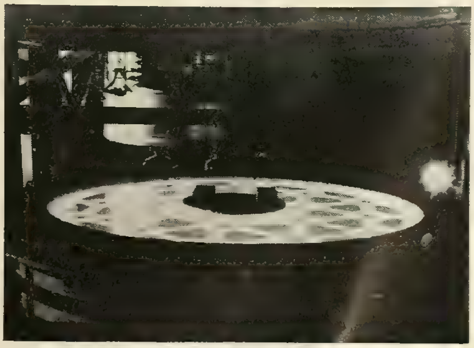
CERAMIC CORES—which had to hold their position under temperatures of about 2300°F—provided a ribbed, or honeycomb, design.



MOLD'S CENTER core had to be reinforced by a steel plate. One reason was this 2796-pound chunk of boro-silicate composition glass.



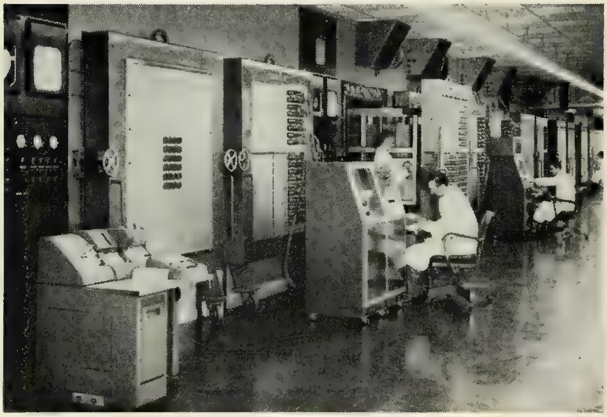
THE FIRST large-sized ribbed disk (84-in. diameter) is made by sagging. Scrubbed clean by sandblasting, glass is now ready for the melting furnace.



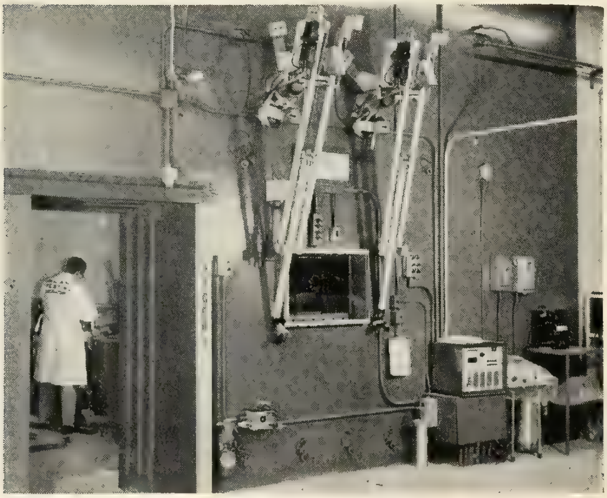
MOLTEN BLANK—weighing almost 4000 pounds—is moved from furnace to the annealing kiln where it will be slowly cooled for seven months.

Cook Labs Do Mass Components Testing

Inland Testing engineers screen up to 100,000 parts simultaneously without damaging those that are acceptable.



A ROW OF Inland's environmental chambers with automation equipment in front of doors. Accuracy is closely checked.



COBALT 60 cells for radiation testing. A gate circuit is used to guard against loss of component identification.

Morton Grove, Ill.—While it is true that quality cannot be tested into a product, engineers of Cook Electric Co.'s Inland Testing Labs say that reliability can.

Leonard L. Schneider and Albert M. Lock contend that reliability of equipment can be upgraded by eliminating submarginal component items from a lot of parts before production. This is accomplished by subjecting all component parts to screening tests designed to identify and segregate parts which will exhibit marginal and/or abnormal performance under field service conditions.

These tests employ environmental, electrical and mechanical stresses to isolate component parts which are not members of a homogenous population, without degradation of acceptable parts. This is essentially a process of truncating a distribution.

Inland's experience with a quarter of a million parts subjected to screening, say Schneider and Lock, has indicated that from 0.1 to 10% of a lot of component parts can be rejected because of anomalous behavior of some characteristic.

• **A new concept**—Inland's approach is that, if screening tests are to be useful, they must be non-destructive—they must neither degrade performance or life expectancy of acceptable parts, nor physically alter the parts, which might make them unacceptable for production use. This type of large-quantity non-destructive testing calls for not only a new concept, but for unusual testing facilities.

Inland Testing Labs have these unusual facilities. Their reliability section can simultaneously test 100,000 components under programed humidity, temperature and power cycling. This chamber capability is accompanied by automated test consoles capable of performing measurements on resistors, capacitors, diodes and transistors at the rate of one meaurement per second. Thus it is economically feasible for producers of high-reliability equipment to have their component parts 100% screened.

ITL's chamber facilities consist of 14 environmental chambers, each of 75-cubic-foot capacity. Since the door assemblies *(see cover photograph)* which may be inserted from the front of the chamber can be transported from one chamber to another, cooling is needed in only two chambers. With this combination, Schneider and Lock say they can accommodate almost any temperature-humidity cycle by appropriate scheduling.

• **Mounting a test**—The components are mounted between specially-designed spring clips which do not deform the leads. These clips are insulated from anodized aluminum terminal boards by teflon inserts. Thirteen rows of 51 positions, uniquely identified, comprise a board, and two or four boards comprise a rack. The racks are inserted into a door assembly which in turn is inserted into a chamber. Placed on dollies, it can be rolled from one chamber to another.

All of the internal wiring from the terminals on the boards to the 52-pin AN connectors is teflon-insulated. When fully loaded, a door assembly will contain approximately 12,000 component parts, connected to the front panel through teflon-insulated cables terminating in 288 Amphenol 52-pin connectors.

To be effective, a screening test must discriminate among components on the basis of permanent changes in characteristics as a result of environmental and/or electrical exposure. Anything other than rapid automated measurement techniques is considered impractical.

The measuring consoles are equipped with cables, one end of each cable plugged into the front of the door assembly and the other end terminating on a scanner stepping switch. The stepping switch successively introduces components to be tested into a programed test circuit. A digitizing voltmeter converts the desired information from analog to digital form and feeds into a card punch. The output of the punch constitutes a permanent data card which is fully identified and contains 4-digit readings of 17 components.

The resistor console is capable of making a total of 2550 resistance measurements without a change of cables and these can be accomplished in about fifty minutes.

- **System checks**—The reliability of the measurement equipment, incorporating many electro-mechanical devices, is in most cases lower than the reliability of the component parts being tested. Hence, the accuracy and functioning of the system must be checked. Before a readout is begun, the digitizing voltmeter or ohmmeter, card punch and associated circuitry are exercised.

The meter is connected across a variable resistor and made to read 00000, 11111, 22222, etc. through 99999. The exercise readings are punched on a card along with code information indicating the relationship of this exercise to the rest of the test program. Precision, pre-aged wire-wound resistors or voltages from standard cells are introduced into the measuring circuitry in the ranges in which component measurements will fall to provide a check on the calibration of the digital meter. These calibration readings are recorded on a punched card with the exercise information and retained as a permanent reading.

COMPONENTS ARE mounted on frames which are part of a chamber door assembly.

A second exercise and calibration card is punched at the conclusion of a run to establish that the measuring equipment is functioning properly.

To further assure that the measuring consoles are performing properly, a dummy component is placed in the measuring console, protected from severe environmental conditions, to simulate the test component. The dummy is introduced into the measuring circuitry at 10-minute intervals during the course of a readout, enabling an engineer to ascertain that the equipment is functioning properly.

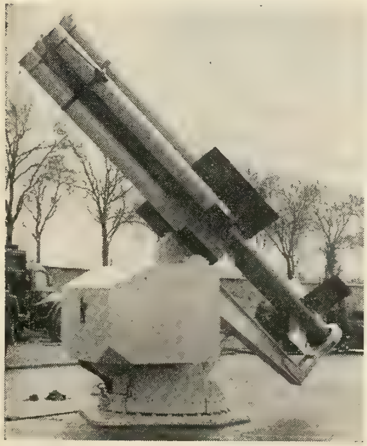
- **Identification safeguard**—Electromechanical devices like those in the scanning circuitry are prone to malfunction—either failing to step or double-stepping—which could introduce serious error in data reduction due to false identification of parts. To guard against loss of component identification, a gate circuit is employed after measurements on each 51 components.

If the sequencing is proper, the scanner control relay is permitted to move to the next 51 components. If a scanning malfunction has occurred, the console will stop. The stoppage will be investigated, corrective action taken, the previous 51 components re-read and the operation continued.

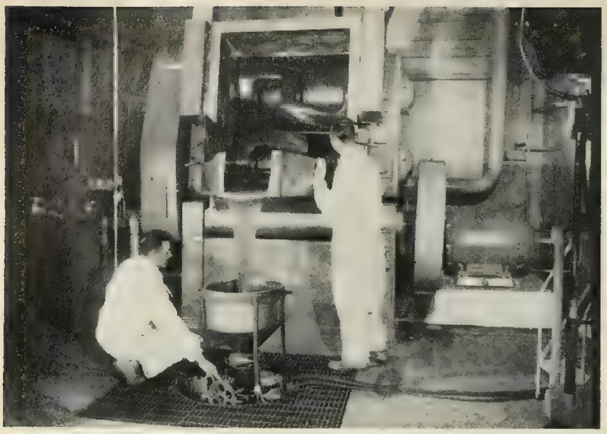
At the conclusion of a run, the deck of cards is taken to the data reduction section where a 650 computer produces a tab run which identifies the positioning of the "bad" components. This data reduction is normally accomplished the same day as a measurement run is made and usually the rejected components are pulled from the door assembly within a few hours after a measurement run has been completed.

- **Missile work**—This describes the facility which Inland now has in operation. Current emphasis is on a program to test all the components going into the *Atlas* computer made by Burroughs. A previous large-scale program was carried out for Remington-Rand Univac. Inland now expects that it will be associated with the guidance program of an upcoming major missile, testing all components of the guidance and control system.

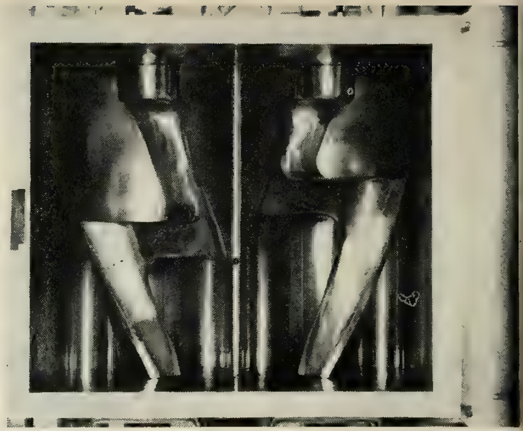
Britain's Deadly *Seaslug*



THIS PHOTO of England's *Seaslug* ship-to-air guided missile was released after a recent demonstration to NATO military personnel in Paris. The missile will be on four guided missile ships now under construction for the Royal Navy. Produced by three companies—Sir W. G. Armstrong Whitworth Aircraft Ltd., The General Electric Company, Ltd., and Sperry Gyroscope Company, Ltd.—it is intended for interception of aircraft at long range. In one firing of a salvo of two missiles, the first destroyed the target aircraft, and the second made a direct hit on the largest piece of the wreckage remaining.



AT THIOKOL's Huntsville plant, operators pour 200 gallons of molten rocket fuel from Baker Perkins mixer.



CLOSE-UP of cast stainless blade of the 17 TSE mixer. Smooth surfaces permit easy cleaning.

Mixing Machines Boost Solid Fuel Output

WASHINGTON—A "growing pain" resulting from rapid expansion in production of solid rocket propellants—the necessity of obtaining a critical blending action of large batches in precise proportions—has been eliminated.

This has been accomplished by the development of large mixing machines equipped with special blades. Designed by Baker Perkins Inc., Saginaw, Mich., they are used in various plants of the Thiokol Chemical Corporation.

•**Solid advantages**—The many advantages of solid fuels have led to recent missile advances. Not only can the solid propellant charge be bonded to the chamber wall of the rocket motors but it can also be shaped into an "internal burn" propellant charge, making possible construction of extremely lightweight rocket motors with thin-walled combustion chambers.

These advantages have resulted in sharply increased production of the fuels. The original method of making small batches in any available equipment had to be abandoned. Both the actual volume of protection required and the need for efficient operation in a competitive market have forced producers to turn to equipment designed specifically for rocket fuel requirements.

These fuels generally consist of a mixture of an organic fuel—a polysulfide material—and an inorganic oxidizer. Solidified into a desired shape, the charge must have sufficient flexibility and strength under temperature extremes to resist the shock of acceleration of the rocket, as well as the shock of adjacent detonation. To meet military specifications, the charge must burn evenly and must not deteriorate during normal storage.

•**Mixing process critical**—All of these requirements are directly or indirectly affected by the nature of the mixing process. The inorganic oxidizer, ground to a critical particle size, must be blended with the polysulfide binder in a precise proportion.

In addition to the normal requirements for a mixing machine, the need to maintain the precise composition of the fuel demands extraordinary cleanliness. No corrosion of construction materials by the inorganic oxidizer or other matter can be tolerated.

Also, since different compositions of various propellants are prepared in the same mixers, it is essential to prevent particles from previous ingredients from mixing with the new batch and changing its composition even by a very small percentage.

•**Cast blades**—Because of these considerations, the mixing blades of the Baker Perkins mixers are made of cast stainless steel type CF-8M (Alloy Casting Institute designation).

As listed in the data sheets of the Alloy Casting Institute, type CF-8M has the following nominal composition: 19% Cr, 10% Ni, 2-3% Mo, 0.08% max. C. This iron-chromium-nickel-molybdenum alloy has excellent corrosion resistance and mechanical strength in a wide range of temperatures and corrosive environments.

The fact that this alloy is available in the cast form is particularly advantageous in the complicated design of the blades, which would be extremely expensive to produce by any other method. Producing this blade from wrought shapes probably would involve welding, which would increase the corrosion problem, possibly to a prohibitive point. Also, casting allows the design of smooth contours, avoiding sharp corners and crevices which act as "traps" for contaminating materials and as focal points for corrosive action.

•**Practical design**—According to John Higginson, General Manager of the Thiokol Chemical plant at Brigham City, Utah, other types of equipment using plain carbon steel blades showed a great deal of corrosion when in contact with the propellant ingredients. When such blades were used, much hand cleaning was necessary between batches to avoid contamination.

For some very viscous fuel mixtures, such as those produced at the Utah plant, Thiokol is using vacuum mixers. Thus, while the materials are in a state of constant agitation, solvents or other volatiles can be vaporized. Also, oxidation of sensitive materials can be prevented by vacuum mixing, since occluded gases can be removed efficiently. In addition, air will not be worked into the mix during the operation. The mixer has a separate hydraulic pressure system which tilts the machine for discharge of the mixed batch.

Cleaning is accomplished by running through a mixture of sawdust, water and detergent.

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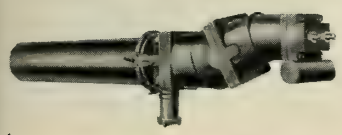
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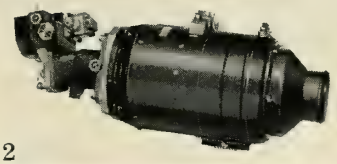
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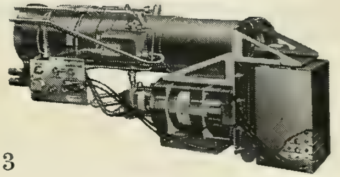
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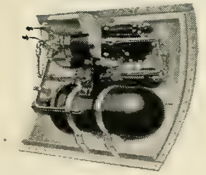
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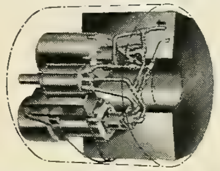
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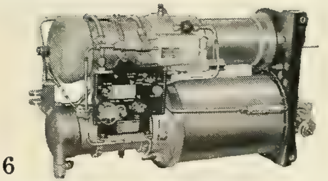
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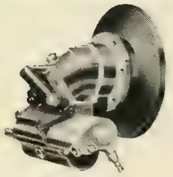
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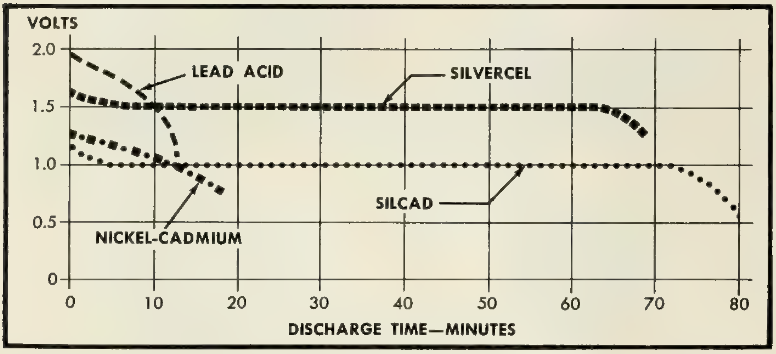
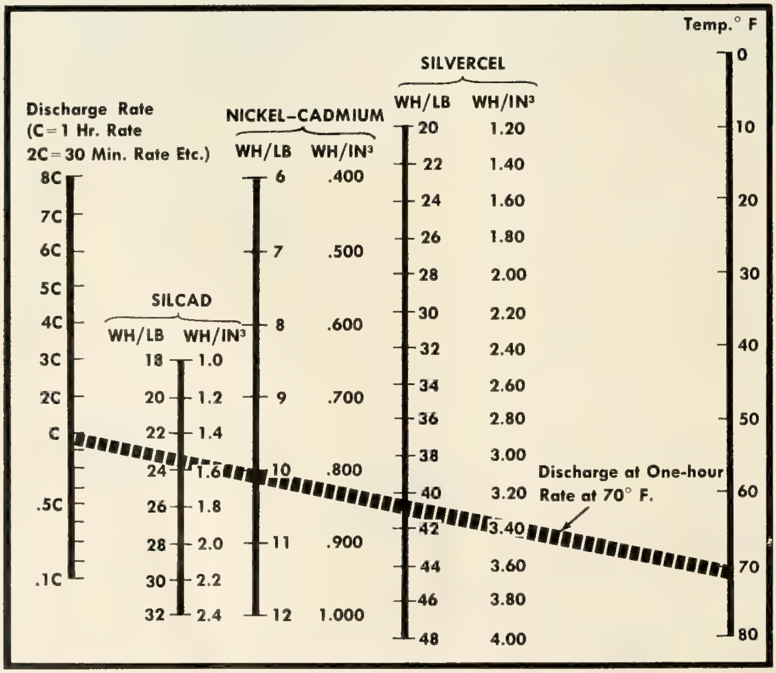
Miniature Batteries Have Heavy Missile Use

Yardney's latest Silvercel may make possible more pre-flight tests for reliability. Early model saw service in *Viking*; many employed in today's birds.



DISCHARGE CHARACTERISTICS of several types of production rechargeable batteries of equal weight delivering the same current. Note the steady "plateau" voltage prevalent throughout most of the discharge of the batteries.



COMPARISON of specific energy of Silvercel, Silcad and Nickel-Cadmium systems.

by Donald E. Perry

NEW YORK—Speak if you wish of future "exotic" power sources for space vehicles, but don't discount the features of today's miniaturized rechargeable electrolyte batteries that are already proving their value in rocketry.

While the battery—unless it is solar-powered—may be considered by some as passé, Yardney Electric Corp. likes to cite present applications—use in *Titan, Pioneer* probes, *Bomarc, Atlas, Jupiter, Polaris, Snark, Redstone, Vanguard, Falcon, Goose, Aerobee* and drones.

Latest Yardney effort is a PM (reusable reserve primary) Silvercel battery in a missile model with an external feed line to fill the battery with electrolyte to activate it only minutes before the missile is fired.

The battery reportedly offers specific energy as high as 70 wh/1b and has been recharged as many as 15 times. This indicates that it would make possible many more pre-firing tests for reliability. The company says it can stay in a missile two months without losing its capacity. It uses a silver-zinc couple and, according to the company, can provide as much power as ordinary batteries five times larger and six times heavier.

The development cycle of the Silvercel is worth mentioning because of its use in early pioneering U.S. space experiments. Equipment in a *Viking* rocket was powered by the battery and photographed the earth from a 158-mile altitude.

The specific energy—under optimum conditions—of Yardney batteries can be compared this way:

	wh/1b	wh/in³	nominal cell volt.
Silvercel	56	3.6	1.5
Silcad	33	2.7	1.1
Lead-acid	20	0.9	2.0
Nickel-Cadmium	13	0.8	1.2

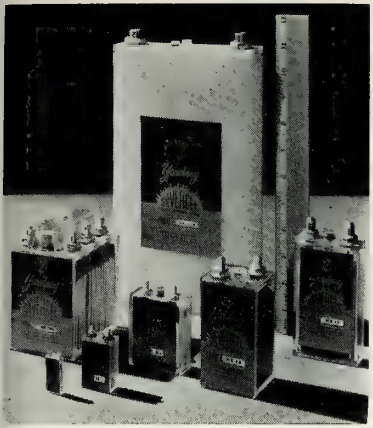


PHOTO SHOWS range of Silvercel sizes.

• **Uses in missiles**—The extent of battery applications for missiles and rockets is shown in the following breakdown by project, type of batteries used, and specific purposes of use. PA is for automatically-activated primary; HR is for high rate; and PM is for reusable reserve primary.

Vanguard uses Type 20xHR 20, 30-volt 20-amp. hour, and others, for telemetering, flight and guidance controls in the first and second stages. Soon there will be a package battery in a *Vanguard* satellite that is non-magnetic. It will operate minitrack, command receiver, magnetometer and telemetering.

The *Astor* torpedo uses a Mark 64, 250-volt 115-amp. hour for all electric power supply, including propulsion and homing devices.

Falcon uses Type 10xHR3, 15-volt 3-amp. hour for telemetering in all R&D tests.

Bomarc uses Type 30xHR 80, 38-volt 80-amp. hour to power a hydraulic pump motor. A double battery, Type 22xHR40-300 and 5xHR20-100 with 27.5-volt 40-amp. hour and 7.0-volt 20-amp. hour, respectively, supplies energy for electronic guidance equipment and elemetering instruments.

Atlas is a heavy user of the bat-eries. For guidance and controls, these ypes are used: Type 20xHR60, 30-volt 0-amp. hour; and Type 20xPM40, 30-olt 40-amp. hour. Range safety command utilizes Type 19xHR1, 28-volt -amp. hour. Telemetering uses include wo double batteries. One set is Type xHR10, 6.6-volt 10-amp. hour and Type 18xHR15, 28-volt 15-amp. hour. The other double battery uses Type 9xHR15, 28-volt 15-amp. hour, and Type 5xHR10, 6.3-volt 10-amp. hour.

The *Mark 39 Torpedo* uses a Mark 5, 60-volt 100-amp. hour battery for ll electric power supply, including ropulsion and homing devices. Other

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MARTIN
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torpedoes and battery types are *Mark 32 Torpedo,* Mark 42, 43-volt 40-amp. hour; *Mark 43-1 Torpedo,* Mark 41, 26-volt 20-amp. hour; *Mark 43-3 Torpedo,* Mark 58, 26-volt 44-amp. hour.

Snark—for controls and instrumentation—uses Type 22xHR10, 30-volt 10-amp. hour.

Under the *Goose* program—now cancelled—two units of Type 22xHR3, 60-volt 3-amp. hour were put in series for controls and guidance in the R&D test program.

Titan will soon have Type 20xPA-50, 28-volt 50-amp. hour, and Type 19xPA3-1, 28-volt 3-amp. hour for telemetering, guidance and controls.

While specific battery information is not available for *Polaris,* use will be multi-purpose.

Redstone has a double battery, Type 20xPA19, 28-volt 19-amp. hour, and Type 19xPA30, 28-volt 30-amp. hour, for guidance controls and telemetering.

Jupiter also uses a double battery Type 20xPA8, 28-volt 8-amp. hour, and Type 20xPA15, 28-volt 15-amp. hour, for guidance and controls. No specific information is available on battery use for telemetering.

Again, there is no specific information on the batteries used for the *Pioneer* shots. However, they will figure in the TV camera, satellite instrumentation and telemetering.

Aerobee uses Type 20xHR1, 30-volt 1-amp. hour; and Type 20xHR3, 30-volt 3-amp. hour, both for guidance, controls and telemetering.

Drones use Type 19xHR5, 28-volt 5-amp. hour; and Type 19xHR15, 28-volt 15-amp. hour for electronic apparatus power, including hit recording and data transmitting.

The following types are used for telemetering on nose cones of various missiles: Type 20xHR5 D. C., 28-volt 5-amp. hour; Type 20xHR20 D. C., 28-volt 20-amp. hour; Type 20xHR1 D. C., 28-volt 1-amp. hour; Type 20xHR40 D. C., 28-volt 40-amp. hour; and Type 4xHR5 D. C., 6-volt 5-amp. hour.

Reds Say *Lunik* Made 'Comet'

by Frank G. McGuire

WASHINGTON—The Soviet Union has issued an explanation, published in Pravda, of the photograph of its *Lunik* taken Jan. 3, 1959. Considerable speculation had been voiced about the photograph for several reasons. The absence of stars in the photograph was questioned, and therefore, the ability of the Soviets to accurately pinpoint the artificial comet's location without stars as reference points.

According to the Russian account, given by I. S. Shklovskiy, Doctor of Physicomathematical Sciences, the weak stars surrounding the "comet" were not registered on the photograph because an interference light filter was used. The determination of the comet's location in the heavens was made through the use of "special reference marks"—presumably through a device in the photographic mechanism.

• **Troubles met**—Pravda cited difficulties in making the photo, principal among these being the weakness of the sun's reflection from the rocket at that distance. It was pointed out that *Sputnik III,* at a distance of 187 miles from earth, appeared as a star of the 4th magnitude. If this distance is increased to 187,000 miles from earth, or a distance 1000 times farther, the reflected sunlight drops to one-millionth because the reflectivity is inversely proportional to the square of the distance.

This means that the satellite *Sputnik III* would appear, at 187,000 miles, as a star of the 19th magnitude. The 6th magnitude is the weakest visible to the unaided eye on a moonless night.

The Soviet author pointed out that the difficulty is even greater when the rocket must be observed and photographed against a bright background, since it would then be near the moon in its last quarter. Observations are possible, in this case, with only the largest telescopes.

In addition, problems arise when attempts are made to photograph such a small object at great distances, using instruments having a small field of view under bright sky conditions.

• **Reported solutions**—"In these circumstances," Shklovskiy says, "the necessity of developing a method of increasing the brightness of the cosmic rocket many times, if only for a short period, arose. The idea for this method was prompted by nature itself through observations of comets whose brightness in some cases far exceeds that of stars.

"This brightness is the result of the capacity of gases associated with the comet to cause intense scattering of sunlight in separate spectral lines and bands. The bright yellow line of sodium is sometimes observed in their spectra."

Calculations made by the Soviet

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Ampex Instrumentation Tape inherits the same versatility and quality which make Ampex first in magnetic tape instrumentation.

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Ampex Instrumentation and General-Purpose Tapes are available on hubs, NAB-type or die-cast magnesium-alloy Precision Reels. Widths of ¼, ½ and 1" are standard on either Mylar* or acetate base, in the following lengths, reel diameters, and base thicknesses:

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10½"	3600	2500
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M&SS

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scientists showed that the mass of gas needed to make an artificial comet visible to the naked eye at a distance of 100,000 kilometers is one kilogram.

Sodium was selected because of its characteristic bright yellow line when emitted. The great advantage in this choice is that sodium scatters light strictly according to a wave length of 0.589 microns (the yellow-orange part of the spectrum)—thus making it possible, by using suitable light filters, to observe the cloud even against a bright background. Such light filters decrease the brightness of sky background intensely, while scarcely weakening the brightness of the sodium cloud.

Thus was an artificial comet created by the Soviet rocket. It was necessary to make certain that in a short period of time the sodium would be vaporized into its atomic state, because its molecules, compounds and ions cannot intensively scatter sunlight. The vaporizer for forming the cloud of atomic sodium utilizes thermite to accomplish vaporization, the thermite being ignited at a predetermined time through a programing device.

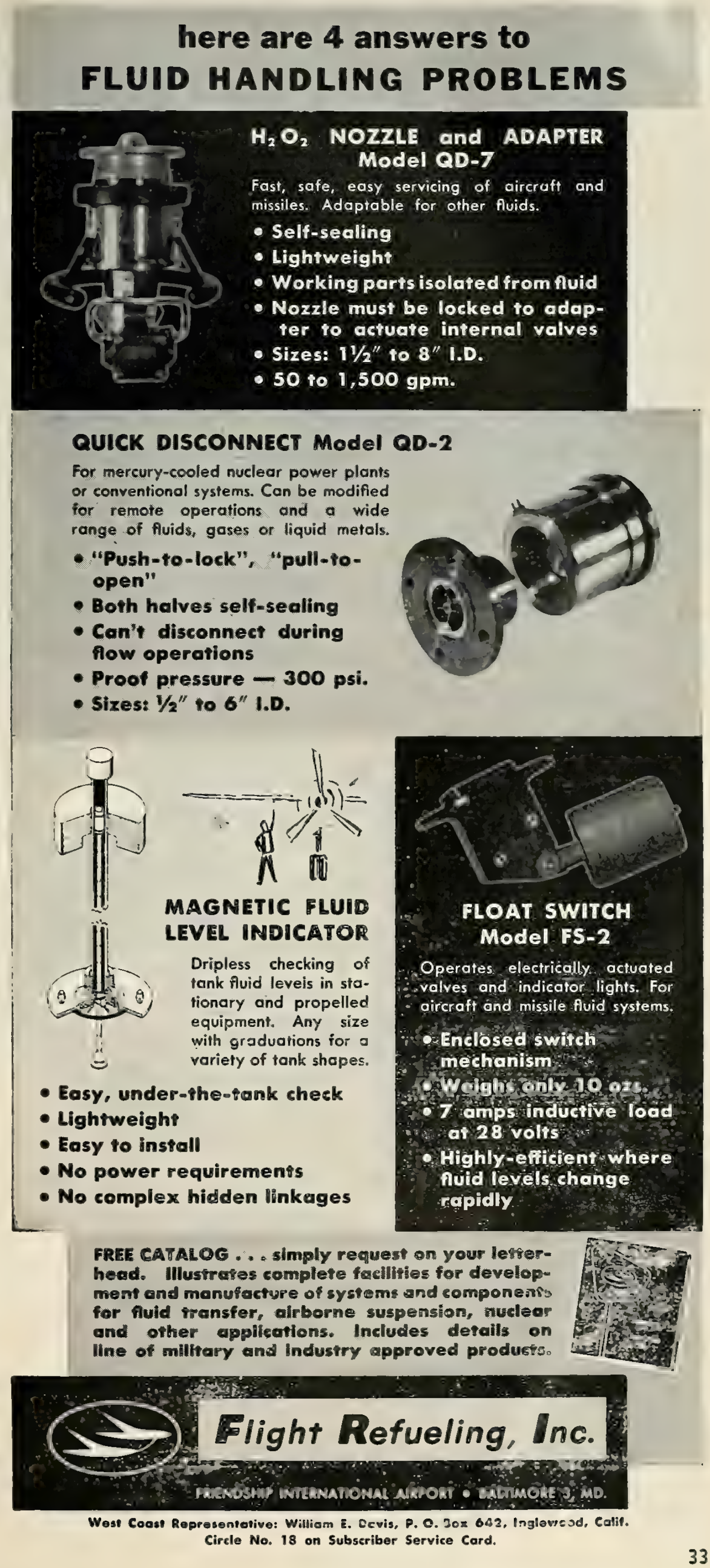
- **Wide visibility**—Preliminary testing of the vaporizer's operation was done with the aid of high-altitude rockets. The sodium vaporized in one of these experiments at 267 miles formed a golden-orange cloud that was said to be visible over a great part of the Soviet Union.

By analyzing the rate of dispersion of the cloud, the Soviet scientists determined the density of the earth's atmosphere at that altitude "with great accuracy." The obtained value of density was in close agreement with the value derived from analysis of the braking action on artificial earth satellites.

United States experiments on sodium vaporization in the atmosphere were begun in 1955 at altitudes of 43 to 87 miles to study the wind and the chemical reactions of gases in these atmospheric layers with sodium.

According to the Pravda article, special cameras were developed and produced for the observations involved in the *Lunik* program. Two series of cameras came from this effort, one photographic and one "electronotelescopic". They were equipped with high-quality light filters and located in various places in the USSR.

At the specified time—03:56:20 on Jan. 3, 1959—the artificial comet was created in several tenths of a second when the rocket was at an altitude of about 70,000 miles. The cloud of sodium was estimated to be 62 miles in size.



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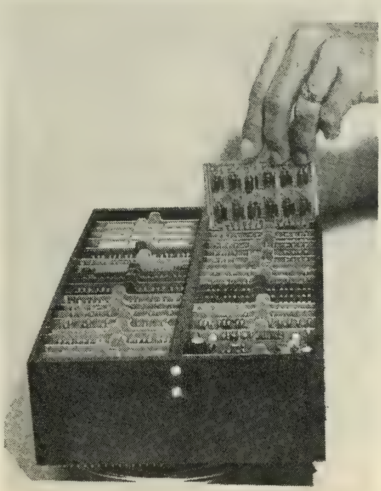
new missile products

Airborne Converter Weighs Seven Pounds



A new airborne, electronic system that weighs only 7 lbs., and is slightly larger than a milk bottle has been developed by **C. G. Electronics Corp.**, a subsidiary of Gulton Industries Inc.

Known as the multi-channel analog-to-digital converter, Model CG591, the new system is purported to be the smallest completely solid-state airborne converter.

Applications include measurements for guidance and stability of flight vehicles such as satellites, missiles, drones and balloons, as well as high-reliability measurements in ground installations for data acquisition and reduction systems.

This completely transistorized converter contains an automatic error checking system and digital readout, and no function is sacrificed in spite of the system's low power requirements.

Utilizing the PCM method of operation, the new system attains accuracies of 0.2% and can be made compatible with any computer code because of its building block construction which uses modular techniques.

Featuring built-in transient surge protection, the converter is adaptable to on-line entry into digital computers which not only saves time, but eliminates errors encountered in the reduction of information.

Other features of the new system are: high accuracy, extreme reliability, low power consumption, small size and weight and modular construction which provides a high order of system flexibility.

Because of the modular construction, a relatively small number of subsystems can be combined to form many systems depending upon application. In effect, custom systems may be formed from standard subsystems.

The systems are formed from small, (2" x 3") plug-in, etched circuit cards which are easily installed or replaced and provide longer life and increased reliability. Outputs can be furnished for magnetic tapes, punched tapes, punched cards, nixie tube readout, or transmission over telemetry links.

Various combinations of circuits, such as flip-flops, mono-or bistable multivibrators, and, or, and not gates, and emitter followers, comprise the desired subsystems. Sub-systems of decade counters, ring counters, command units, parity checkers and the like, constitute the complete analog-to-digital converter.

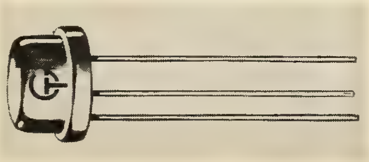
Normally designed to receive 12 inputs, 50 or more can be scanned depending upon the scan rate required. The binary coded decimal form of transmitting information requires only seven discriminators, independent of the number of transducers scanned. The scan rate ranges from 100 to 300 cps. with possible response rates as high as one megacycle.

Designed to measure analog voltages, the a to d converter has a volume of .17 cubic feet (7" x 3" x 14"). Read in sequence, the encoder converts each analog voltage to its digital equivalent which is translated into decimal form. Through the use of amplifiers or attenuators, voltage ranges other than those specified can be handled by the unit.

Circle No. 225 on Subscriber Service Card.

Silicon Unit Produces High Speed, High Gain

A high-speed, high-gain, silicon PNP alloy junction transistor to meet industrial and military needs has been developed by the **General Transistor Corp.** Now in pilot production, the unit will be commercially available in quantity by the spring of 1959.



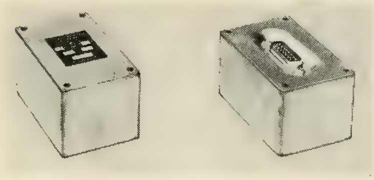
Good switching and gain characteristics, coupled with low saturation resistance, are predicted for the device, which will be packaged in a TO-9 case.

Development of the unit has significance beyond its use in dc amplifiers and other linear applications, since it will make the use of silicon possible in such further applications as direct-coupled and resistance-coupled transistors and other extensions of transistor logic.

Circle No. 226 on Subscriber Service Card.

Oscillator Designed for Many Airborne Uses

Data-Control Systems, Inc. has announced the availability of its new model AOV-4S Airborne Voltage-Controlled Oscillator, which has the same circuitry and performance as Model AOV-2S in a new physical configuration, compatible with many existing airborne packages.



The unit has a silicon junction diode network and silicon transistors,

NOTE: *For additional information about any product mentioned in this section of Missiles and Rockets use the attached prepaid reply cards. Circle numbers shown on the reply card that correspond with numbers appearing beneath items described. If no circle number accompanies the article or advertisement, give page number (and advertiser's name) on line provided at bottom of card.*

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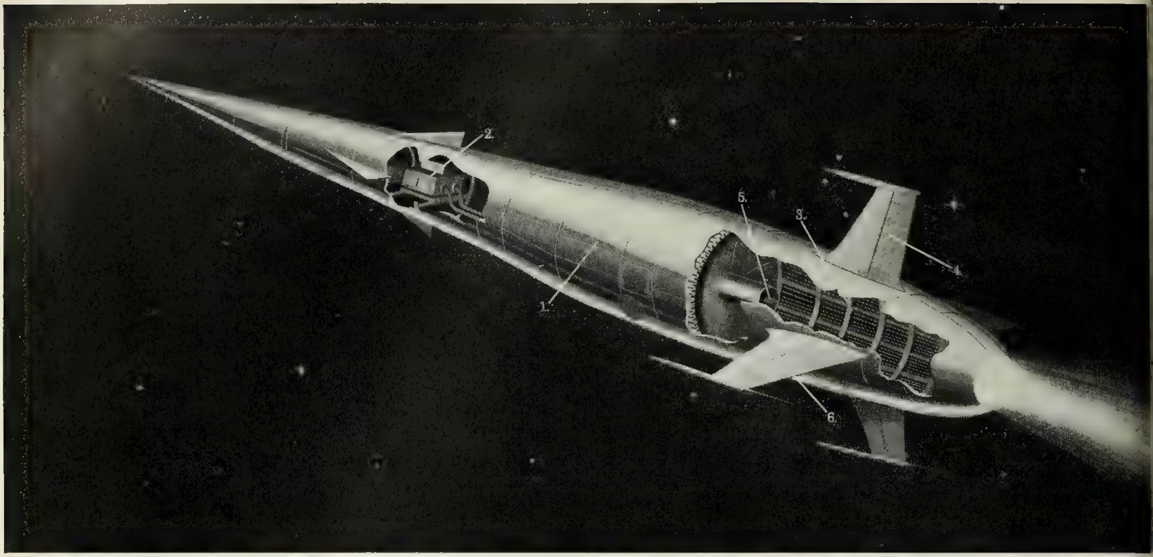
The Editor

DOW | MAGNESIUM



Design a missile with light, strong magnesium alloys

1. **SHEET** for internal or external skins of body.
2. **DEEP DRAWN HOUSINGS AND CASTINGS** for guidance and other instrumentation.
3. **CASTINGS AND EXTRUSIONS** for body frame.
4. **CASTINGS AND EXTRUSIONS** for fin and wing construction.
5. **ROUND EXTRUDED TUBING** for integral body sections.
6. **SHEET** for external skins of fins, rudders and wings.

THERMAL PROPERTIES OF LIGHTWEIGHT MAGNESIUM

offer advantages to missile men

Most engineers are aware of the advantages available to them when they combine magnesium's light weight with its good mechanical properties at elevated temperatures up to 800°F. There are, however, other advantages such as thermal properties that are less well known. They, too, can be of real value to missile designers. In many cases they will open new areas in design previously considered closed to magnesium.

Let's consider one of these, magnesium's high specific heat and its relationship to missiles. This can mean lower temperatures for given flight conditions. As a result magnesium can be used under very severe flight conditions for short time applications. (See Fig. 2.) This permits the use of magnesium in high speed missiles which are exposed to heat generating atmosphere for only a matter of a few seconds. With magnesium acting as a heat sink it can result in reducing environmental temperature for electronic instruments.

Magnesium offers other thermal properties that are of value in aircraft and missile design. For example, the thermal diffusivity of magnesium-thorium alloys $\left\{\frac{\text{Thermal conductivity}}{\text{Specific heat x density}}\right\}$ is high and remains fairly constant over a large temperature spread. Between 68° and 900°F. the thermal diffusivity of these alloys is in the range of 0.57 and 0.75 cm.^{2}/sec. (2.2 and 2.9 ft.^{2}/hr.)

For more complete data send for Bulletin 141-187 "Magnesium Alloys for Elevated Temperature Use." Contact your nearest Dow Sales Office or write to THE DOW CHEMICAL COMPANY, Midland, Michigan, Department 1300CL2-23.

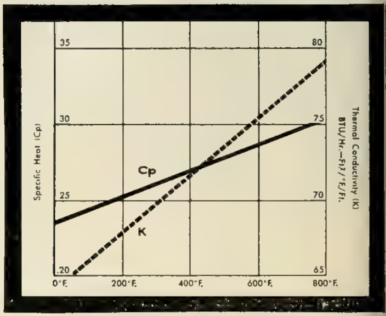


Fig. 1. Specific Heat and Thermal Conductivity of Magnesium-Thorium alloys.

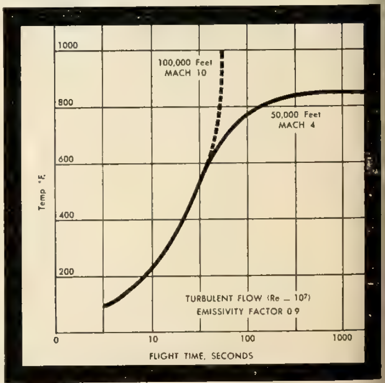


Fig. 2. Effect of Structure Temperature and Flight Time on Mg-Th Sheet Alloys at Mach 4 and 50,000 Feet and Mach 10 and 100,000 Feet.

THE DOW CHEMICAL COMPANY • MIDLAND, MICHIGAN

Circle No. 20 on Subscriber Service Card.

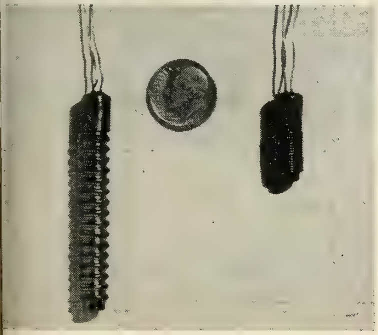
which permits use in ambient temperature to 125° linearity for the unit is ±0.5% maximum deviation from best straight line and low power drain and high stability in cases of supply voltage variations. Dimensions of this miniaturized oscillator are 3" by 1.62" by 1.87".

Circle No. 227 on Subscriber Service Card.

Miniature Bellows Motor Works Around Curves

A powerful miniature, squib-actuated bellows motor which provides positive displacement for the performance of mechanical work has been developed by **Atlas Powder Co.**

The motor is .320-in. in diameter and 1-in. long. Actuated by as little as 100 ergs at 1.5 volts, or 0.3 amps, the motor is capable of providing 10 lb. of thrust over a 1-in. minimum stroke within an elapsed time of 1 millisecond. In addition, the bellows can be guided around a 90 degree curve.



The motors are extremely reliable. They will function properly from –65 to +165 F and will withstand 20,000 g's shock and acceleration. Shelf life is measurable in years.

Circle No. 228 on Subscriber Service Card.

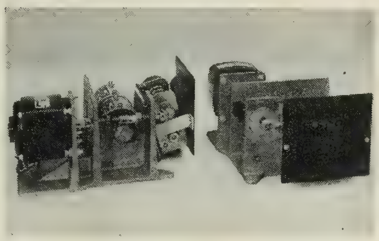
Servo Designed for Auto-Null Balance Systems

A new servo assembly is being offered by **Datran Electronics** for use by designers of automatic null balance systems.

The aluminum casting assembly includes a Holtzer-Cabot 4 pole 60 cycle servo motor, drive coupling, shaft, bearings and gear drive assembly, digital counters with automatic shutter action to indicate plus or minus digital output, and one or more balance or output potentiometers. Synchro output and/or a Coleman Decimal Digitizer is also provided as optional equipment.

An unusual and easily adjusted limit stop mechanism positively eliminates damage to the balance potentiometers due to off-scale input signals.

This assembly, which includes a black fibreglass bezel for panel mounting, eliminates the necessity to spend valuable engineering time to package this combination of electrical and mechanical components into a compact and proven configuration. Models are available with various full-scale range of counts and speed.



Circle No. 229 on Subscriber Service Card.

Lightweight Calibration Unit Designed by Ampex

A fully portable, all semi-conductor device intended for precision alignment and calibration of electronics equipment such as FM record/reproduce systems has been introduced by **Ampex Corporation's Instrumentation Division.**

The new calibrator, designated TC-10, contains a voltage standard accurate to 0.01%. Working calibration voltages are available in nine steps, each adjustable over a range of 10%. Nine precision oscillators and seven binary dividers provide 63 accurate calibration frequencies ranging from 1012 cycles to 151.2 kc. These can be introduced into a system for discriminator alignment or for comparison with the output of a voltage-controlled oscillator.

According to Ampex spokesmen, the 25-pound, fiberglass-housed unit was especially designed to withstand the rigors of field use. They described its highly stable and accurate voltage system as "an important advance in test instrumentation."

Circle No. 230 on Subscriber Service Card.

Oscillator Adjusts Against Crystal Aging

The Model RD-146, a new version of the **Manson Laboratories'** RD-140 one-megacycle high stability oscillator, contains a calibrated trimmer control for making accurate frequency adjustments against crystal aging, on a daily, weekly or other frequent time period basis, without comparison to WWV or other standard.

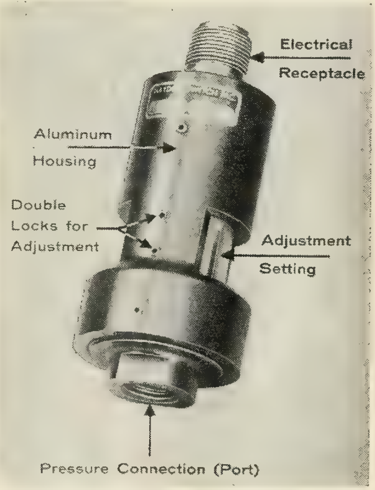
Operation of the dial, which has a readability accuracy better than two parts in 109, may conveniently be related to the instrument's known drift rate, thus greatly extending the time interval for absolute re-adjustment to 1 mc. The dial is also useful in applications requiring a small range of tunability, as the output frequency may be varied and accurately set over 6 cycles.

The oscillator, employing a quartz resonator under proportional oven control, furnishes a 1 mc output stabilized to better than 1 part in 108 per day; extended usage results in even lower drift. External B+ and filament power are required, but the instrument's relatively high insensitivity to input voltage fluctuations permits the use of almost any unregulated power source of suitable capacity.

Circle No. 238 on Subscriber Service Card.

Switch/Transducer Has Varied Missile Uses

Haydon Switch Co., has announced the 1500 series pressure switch/transducer. The new unit is designed to meet the requirements of aircraft, missiles and rockets. Applications include lubricating, pneumatic, hydraulic, fuel, chemical and gas pressure systems.



All moving parts are contained in aluminum housing, environmentally-sealed by O-rings at each end. This assembly, weighing only 3 ounces, can sense pressure levels from 0.5 to 4000 psi merely by changing internal modular components. Eight switches will

...NEWS IS HAPPENING AT NORTHROP

FIRST LOW-COST SPACE AGE AIRCRAFT
DEMONSTRATES NORAIR SYSTEMS MANAGEMENT CAPABILITY

The twin-jet T-38 –America's first supersonic trainer–aptly demonstrates Norair's capability in systems management. Now in production under USAF contract, the T-38 Talon is the first member of a Northrop-conceived family of lightweight, low-cost space age aircraft.

Soon to follow: a supersonic counterair fighter, the N-156F – first weapon system designed in America for the specific tactical and economic requirements of those free allied nations most vulnerable to enemy attack.

Other important systems management achievements include the USAF Snark SM-62A and the F-89 Scorpion. Norair management of the Snark program produced the free world's first operational intercontinental guided missile – delivered on time and at minimum cost.

In producing America's first nuclear-armed interceptor, Norair's weapon system management of the F-89 was marked by on-time delivery of more than 1,000 units throughout the program's life, and by a significant dollar underrun. A full ten years after its first flight, the Scorpion is still the USAF's most heavily armed interceptor – and a uniquely stable platform for air-launch of atomic rockets.

Norair's cost-proved record of effective management, integrated facilities, and available resources combine to demonstrate outstanding capability as a prime systems contractor.

NORAIR *formerly Northrop Division*
HAWTHORNE, CALIFORNIA
A DIVISION OF NORTHROP CORPORATION

Circle No. 21 on Subscriber Service Card.

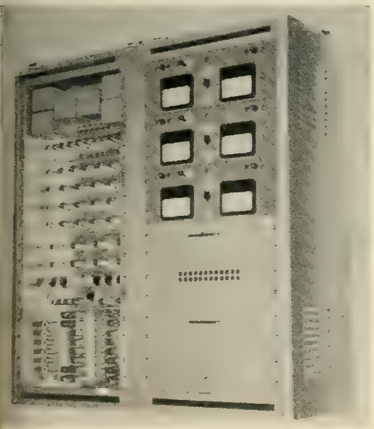
cover the complete pressure span. Exact calibration of each switch assembly is obtained by rotating the external pressure setting adjustment, which is then securely locked by two set screws.

The unit meets MIL-E-5272A specifications. The entire assembly is resistant to corrosive operating media, for example, water-alcohol solutions, nitric acid and hydrogen peroxide. An optional mounting bracket provides vibration isolation up to 2,000 cps and up to 50 g's.

Circle No. 231 on Subscriber Service Card.

Automatic Electronic Unit Compares Input Signals

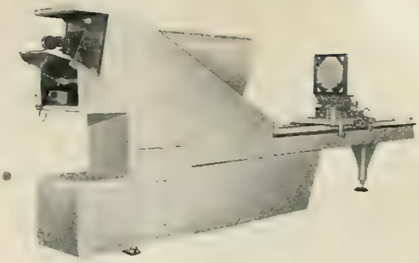
A new electronic unit which automatically compares two input electronic signals that consist of digital pulses, subtracts them, and presents an analog signal output representing the difference between the two has been produced by the **Computer Equipment Corp.**



The digital subtractor-converter combines analog and digital data processing techniques, using each method in areas known to be appropriate. Each of the two input channels will accept positive voltage pulses, zero to 30 volts in amplitude. Repetition rates of from zero to 4095 pulses per block or data word are accommodated, with 30 blocks per second handled by the system.

The analog output voltage, which may be used to operate servocontrolled pattern followers and precision positioning systems, performs digital null detection and program comparison, or n many other applications, is accurate to 12 bits of input information. The scale factor is 50 millivolts of output amplitude change for one bit difference between input channels.

In operation, Model DS-12-A accepts input pulse signals at bit rates anging up to 250 kilocycles per sec-



Presenting

A VERSATILE OPTICAL BENCH FOR CHECKING BOTH VISUAL AND IR SYSTEMS

Davidson has added another timely development to its growing family of optical equipment with the new Infrared Collimator Bench, Model D-278. Equipped with a Barnes infrared source and a visible light source, the D-278 tests lenses and assemblies in both the visible and infrared wave length regions. Designed as a large reflective-type collimator, it emits a 15.5 inch diameter collimated beam with a maximum deviation from parallelism of 2 seconds of arc over the entire field of view. The collimated beam is projected parallel to the ways of a large, precision, optical bench. A nodal slide, which may be traversed along the rails of the bench, gives precise longitudinal, transverse, and circular movements. By this means, large optical systems may be set very precisely on their nodal points.

Every day Davidson's experienced engineers are assisting manufacturers to solve their optical tooling problems. Without obligation, let them help plan your optical tooling. Simply write or phone our Sales Engineering Department.

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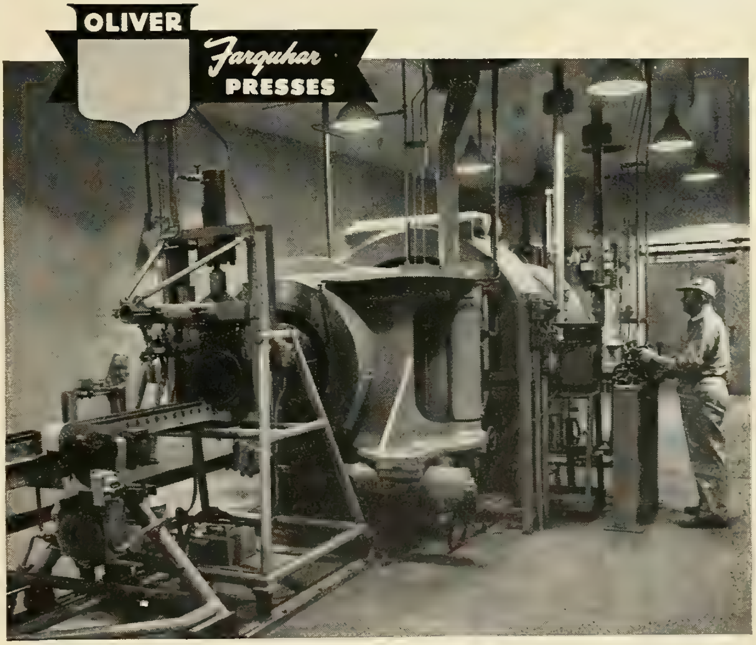

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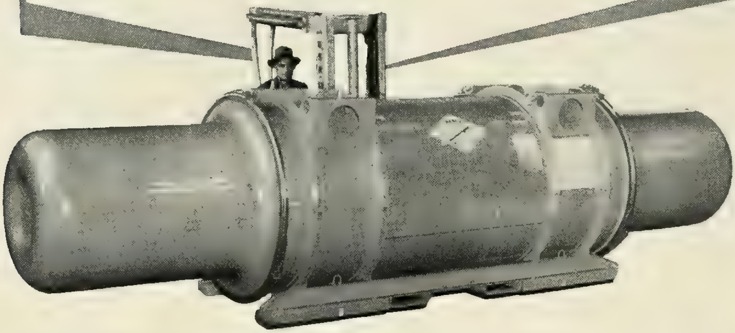
fiberglass
HARCO CONTAINERS

for transport, storage and ground handling of

in-flight refueling stores,
missiles and rockets,
jet engines...accessories

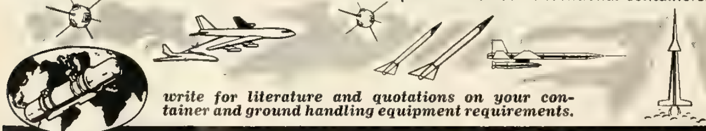
60% LIGHTER IN WEIGHT!



HARCO CONTAINERS ARE THE *ONLY* fiberglass containers approved by BuAer for handling in-flight refueling stores. Far lighter in weight than steel containers, they also transport the Harco developed ground handling trailer for moving of stores from container to aircraft. Type 1500 Harco Container is 18½-feet long, 4½-feet diameter. Unique design of end sections permits reversing and telescoping into center section for empty-return shipment, reducing length to less than 10-feet.

Harco Containers can be stacked three high for conservation of storage space; provision is made for sling or fork-lift-truck handling.

Note end sections reversed for empty shipment. Seven Harco containers with their integral ground handling trailers can be shipped in the same space required for three conventional containers.



write for literature and quotations on your container and ground handling equipment requirements.

Harco Containers
A DIVISION OF HARBOR BOAT BUILDING CO.
258 CANNERY STREET, TERMINAL ISLAND, CALIFORNIA

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ond at either or both of its high impedance inputs. These pulses may represent various quantized analog information; e.g., radar range, azimuth or elevation.

The inputs may be asynchronous, since the digital subtractor converter performs its subtraction only after each block of information is completely loaded. This makes the unit particularly useful where two separate, non-synchronized electrical signals exist, but whose characteristics with respect to each other must be known accurately at all times.

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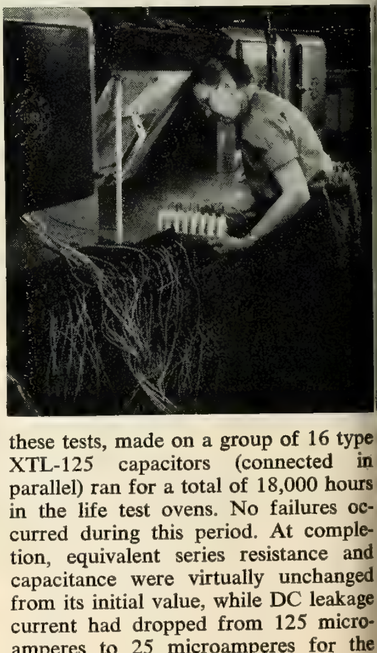
Tantalum Capacitors Run 18,000 Hours

A series of extended life tests recently completed by **P. R. Mallory & Co. Inc.,** have demonstrated the reliability of the company's high-temperature tantalum capacitors. Longest of these tests, made on a group of 16 type XTL-125 capacitors (connected in parallel) ran for a total of 18,000 hours in the life test ovens. No failures occurred during this period. At completion, equivalent series resistance and capacitance were virtually unchanged from its initial value, while DC leakage current had dropped from 125 microamperes to 25 microamperes for the parallel connected package.



Extended life tests are used consistently by Mallory, not only to verify quality but also to correlate data from accelerated testing with actual life expectation.

In addition, all Mallory tantalum capacitors receive 100% inspection of basic electrical characteristics, and statistical sample quantities from every production lot are given tests for DC leakage, equivalent series resistance, capacitance at room temperature and at +175°C and –55°C, under MIL

Autometric
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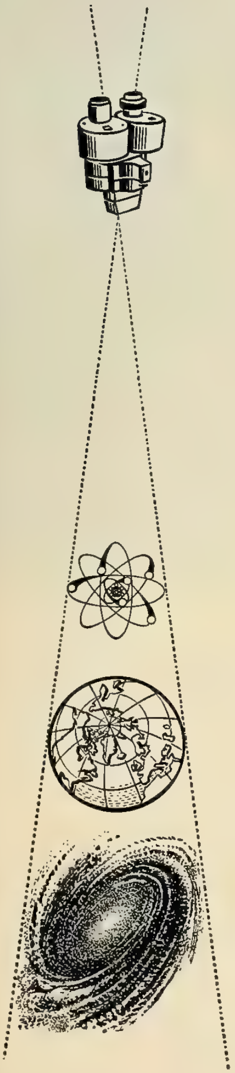
PAUL RAIBOURN
PRESIDENT



Eighteen months ago Autometric announced that it holds "proprietary rights in and manufactures apparatus for pre-programmed control of actual universes, particularly where wayward or inimical autochthons cause capricious responses to control stimuli."

This statement was an appeal to those scientists who recognized its precise technical language to join us. Their response was gratifying.

With their aid, Autometric's capabilities for getting answers simply and directly have been developed. These have been proven by numerous flights and by geophysical measurements which were then compared with the best previous work of many men with analogue and digital aids.

As a result, we now hold large prime contracts for geophysical work in partnership with several of America's largest corporations. We are being requested to become active in other projects of unusual size and significance. We face difficult practical problems of expansion.

In handling these masses of complex data, we have problems of rapid computation and of miniaturized storage and presentation of undigitalized information and abstractions therefrom.

Basically however, we are working beyond such problems since the tough practical decisions demanded by the work-a-day world seem invariably to present themselves in terms of conflicting and incoherent data. A best decision under such conditions is our goal.

We would like to hear from individuals and organizations whose capabilities and experience will be of help to us. Please write in confidence to Robert Dressler, Vice President. Your inquiry will receive personal attention. We are a family of people, not an institution.

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System	O/F (lb. per lb.)	Specific Impulse (second)	Condition
PF—Hydrazine	1.1	274	600# frozen
PF—UDMH	2.55	273	600# frozen
PF—JP4	4.03	255	600# frozen

Write for complete technical data on "PF"

Commercial Development Department 721, Technical Division
PENNSALT CHEMICALS CORPORATION
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Pennsalt Chemicals
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specification C-3965B—after which they get a 2000-hour life test at 85°C and 175°C.

The Type XTL capacitors are part of a line of twelve different tantalum types made by Mallory. Included in this line are many models rated for temperatures as high as 200 C. These extreme temperature ratings, supplied only by Mallory, have been in commercial production since 1949.

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Miniature Coil Produces Full Range of Inductances

A new 11 miniature R. F. Choke Coil known as the wee-ductor has been announced by **Essex Electronics.**

The tiny new choke covers a full range of inductances from 0.10 uH to 1,000 uH, yet it measures only 0.150" in diameter by 0.375" long, occupying a volume of less than 0.0066 cubic inches. The wee-ductor design allows for a high current rating at 125°C operating temperature. Because of its unique new design construction which consists of a high permeability ferrite sleeve and core sealed in epoxy resin for moisture resistance to MIL-C-1505A, the new choke covers a wider range of inductances in a small package size.

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New Cathode Ray Tubes Have Varied Applications

Sylvania Electric Products, Inc. has announced the addition of nine multipurpose cathode ray tubes for military, industrial and commercial applications. The additions include tubes for oscilloscope, materials processing and radar indicator applications.

Type 3RP1A is a flat face oscilloscope tube with electrostatic focus and

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His name is Robert Ulrich. He's the Senior Project Engineer on Fuel Injector Development with Delavan. He's been with Delavan ten years, and has designed fuel injectors which are now standard on many of the world's most advanced jet aircraft and missiles. Men like Bob Ulrich, concentrating their considerable talents to fuel injector development, have made Delavan the world's largest nozzle specialist. They're the main reasons leading turbo-jet, rocket and APU manufacturers rely on Delavan for fuel injection problem solving.

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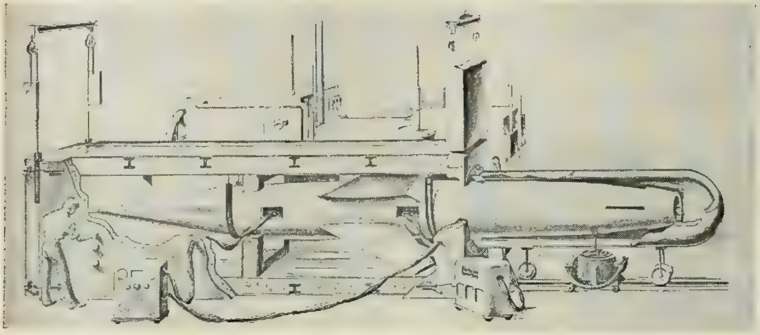
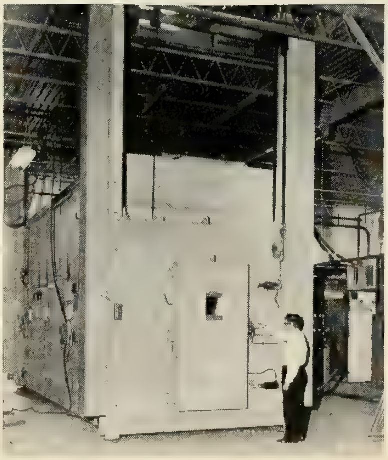
ENVIRONMENTAL TEST CHAMBERS
FROM THE CONRAD Inc. FILE



THE IDEA FROM THE CUSTOMER

From The Martin Company in Orlando came the design specifications for an environmental chamber required for missile testing. Drawing upon years of experience in this specialized field, and working closely with The Martin Company, Conrad developed the walk-in chamber illustrated below.

THE RESULT FROM CONRAD, INC.



Delivered to The Martin Company recently, this 1200 cu. ft. Conrad chamber is sectionalized to produce high and low temperatures simultaneously. It consists of three units—main chamber, machinery, and instrument panel. The main chamber can be divided into two chambers with a pressure barrier separating the sections. Temperature range, -120° F. to +650° F., altitudes in excess of 125,000 ft., capable of dissipating 40,000 watts at -100° F.

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CONRAD Inc.

HOLLAND, MICHIGAN
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deflection. It uses a P1 phosphor with green fluorescence and medium persistence.

Type 5WP11 is an oscilloscope tube for visual or photographic observation. It has magnetic deflection and electrostatic focus.

Types 5AHP14, 5AHP14A, 5AHP19 and 5AHP19A are round glass type high resolution tubes which use electrostatic focusing and magnetic deflection. These tubes differ only in their screen phosphors.

Type 5ZP15 is a flat face high resolution tube with electrostatic focus and magnetic deflection designed for use as a flying spot scanner. It uses a P15 phosphor with blue-green fluorescence and extremely short persistence.

Type 5ZP24, designed for color flying spot scanning, has electrostatic focus and magnetic deflection. It has a clear non-browning faceplate and an aluminized screen. The tube's P24 phosphor is of blue-green fluorescence and extremely short persistence.

Type 7MP14 is a clear face, round glass, non-ion trap radar indicator tube with magnetic focus and deflection.

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Magnetic Amplifier Has Varied Missile Uses

A new Variable Output Magnetic Amplifier for aircraft and missile use has been developed by the **Vap-Air Aeronautical Products Division** of **Vapor Heating Corp.** It is purported to be the smallest in size and weight of any unit of this type available. It has an output of from 0 to 2000 watts.

The Variable Output Magnetic Amplifier can be used in many aircraft and missile systems including windshield temperature control, heater control, and motor speed control.

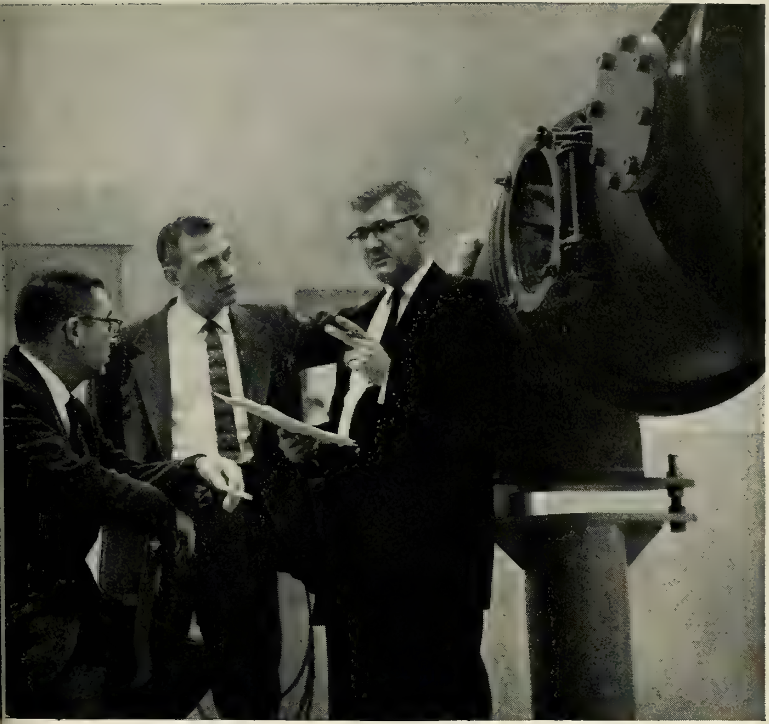
The reported advantage of the Variable Output Magnetic Amplifier over the on-off type is the modulating output, eliminating power surges in the aircraft or missile electrical system.

Combining the functions of these units into a single control eliminates, 1) extra AN Connectors and harness to tie them together, 2) moving electrical contacts in the control box and contactor, and 3) installing three units.

The controller also offers fail-safe features which will shut the controller off in the event of loss of power, pickup short, or pickup open.

In addition to these advantages, the Variable Output Magnetic Amplifier has the ruggedness which is characteristic of mag-amps. The unit will meet

(right) Part of giant capacitor bank used to fire "hotshot" tunnel. Bank is capable of 5 million kilowatt jolt.



(above) Lockheed's "Hotshot" tunnel — only one in private industry.

(right) Research and Development facilities in the Stanford Industrial Park at Palo Alto, California, provide the latest in technical equipment.

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Lockheed capabilities in thermodynamics and gas dynamics are unsurpassed in private industry. Basic work is being performed on problems relating to missiles and spacecraft under simulated conditions of upper atmosphere and outer space. Studies include: boundary layer flow and heat transfer; cooling and insulation; thermodynamic instrumentation for flight test; design of rocket motor controls and nozzle structures; re-entry thermal protection; materials specification; and thermal environments of electronic, mechanical and hydraulic equipment. Also under study are new methods and improved techniques of thin film thermometry, measurements of dissociation and combination of nitric oxide and high-speed shock wave flows.

Equipment includes the fastest wind tunnel in industry, fired by 20 million kilowatts; a hydromagnetic tube which produces velocities of over Mach 250 and temperatures approaching 500,000°K; a "hotshot" tunnel for shock wave, gas and heat studies, capable of velocities of 16,500 mph and temperatures above 12,000°F; and a ballistic range on which projectiles are fired at speeds up to 20,000 ft/sec.

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the requirements of MIL-E-5272A, is adjustable over a wide range, has the built-in reliability which mag-amps offer, and features extreme accuracy and repeatability of operation in ambients of minus 65° to 200°F.

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Amplifier Permits Use of Only One Instrument

Development of a new low level DC amplifier that will permit the use of one instrument instead of many, has been announced by **Engineered Magnetics Division of Gulton Industries, Inc.**

The completely transistorized DC amplifier, Model EM-2000A, is a chopper amplifier not of the magnetic or mechanical chopper types. Designed for use with devices measuring low level phenomena, as for example, thermocouples and strain gauges, the new units are suited for airborne applications because of lightweight, ruggedness, high frequency response and a low power requirement of less than two watts.

Developed for use in systems where excellent sensitivity and frequency response are required, the new DC amplifiers are subminiature in their mechanical characteristics, occupying 27 cubic inches and weighing only 12 ounces.

The unit has a higher frequency response (better than –3DB at 2,000 cps), and thus provides greater economy where larger band widths of low level data are to be amplified. With standard equipment, it is now necessary to amplify each low level signal before multiplexing into a common channel. With the new EM-2000A, DC amplifier, multiplexing may be done at the amplifier input, thus permitting the use of one amplifier instead of many.

The high sensitivity of the new amplifiers permits accurate temperature measurements as low as –95°C with the Iron Constanton thermocouples, and –122°C with Chromel-Alumel thermocouples. The new units are also compatible with strain gauge transducers for high frequency shock and vibration measurements.

Additional characteristics of the equipment include: input sensitivity, 0 to 5MV, + 2½MV, zero is adjustable over a 2.5 volt output range; linearity of + 0.5% from best straight line; gain stability + 1% full scale; floating input and output, and good long term zero stability. The gain is 1000.

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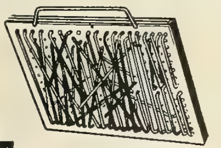
DIT-MCO's exclusive cross-reference Matrix Chart automatically pinpoints each circuit flaw and puts clear, concise test information directly in front of the operator! Horizontal and vertical indicator lights cross-reference on the matrix square corresponding to the circuit under test. This square details type of flaw, circuit number and exact error location. Once an error is detected, the operator immediately marks it on the matrix square, resets the Universal Automatic Circuit Analyzer and continues the test.

All corrections are made direct from the Matrix Chart after the test sequence has been completed. This saves up to 90% correction time by eliminating time consuming searches through diagrams, manuals or interpretive readout devices. Because the DIT-MCO Matrix Chart is a simple, concise representation of all test circuits, specifications, instructions and modifications, *nothing* is left to chance or guesswork! The comprehensive nature of the Matrix Chart system provides important data for statistical analysis and permits *effective* checks and balances ... from the drafting board to obsolescence!

DIT-MCO, Inc. employs an experienced staff of sales engineers in the field. Contact your field engineer or write for important facts about DIT-MCO Electrical Test Equipment.



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contract awards

ARMY

$1,650,000—**Telecomputing Corp.** of Los Angeles, for precision gyros for *Nike-Hercules* and *Nike-Ajax* missiles (add-on contracts from **Western Electric Co.**).

$1,285,000—**Chrysler Corp.,** for additional *Jupiter* components.

$1,000,000—**Rocketdyne Div.,** North American Aviation, Inc., for rocket engines for ABMA's clustering project.

$596,369—**Radioplane Co.,** Van Nuys, Calif., for target drones.

$264,680—**Harvey Aluminum,** Torrance, Calif., for engineering and fabrication.

$243,980—**Western Electric Co.,** for R&D.

$200,000—**The Conkle Construction Co.,** Rosamond, Calif., for G.E.E. maintenance building at Vandenberg AFB.

$164,647—**Gilfillan Bros.,** Los Angeles, for engineering services.

$161,514—**Ford Instrument Co.,** Long Island City, N.Y., for development, engineering and design services on basic guidance and control design information.

$152,927—**Magline, Inc.,** Pinconning, Mich., for *Redstone* missile shelters, lightweight system.

AIR FORCE

$949,000—**Autonics Div.,** Bell Aircraft Corp., for design, development, fabrication and testing of high-performance inertial navigator, The Hipernas II and applicable spare parts, technical reports and engineering data for use in Army surveillance drone program and AF satellite launch and space vehicle program.

$877,430—**Sperry Gyroscope Co.,** for klystron tubes.

$504,237—**General Electric Co.,** for thermocouple assemblies.

$242,000—**Hughes Aircraft Co.,** Tucson, for additional facilities for *Falcon* production.

$229,445—**Gilfillan Bros., Inc.,** for modified search antenna kit including circular polarization.

NAVY

$2,145,772—**Lear, Inc., Grand Rapids, Mich., Div.,** for controller assembly.

$1,380,000—**Manderbach Construction Co.,** Glendale, Calif., for construction of maintenance hangar at Pt. Mugu.

$729,662—**American Bosch Arma Corp., Chicago Div.,** for *Talos, Tartar* and other switchboards and FC switchboard section. (with electric devices and wiring deleted).

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west coast industry

by Fred S. Hunter

Subcontracts are beginning to show up on the *Nike-Zeus* project. One of the stipulations laid down by the San Diego city council in approving Narmco Manufacturing Co.'s purchase of the first plant site in the city's new industrial park calls for construction of a 50,000-square-foot manufacturing facility upon receipt of a production contract from Western Electric. Narmco is one of a group of companies picked by Bell Telephone Laboratories to contribute to the development of a prototype of the *Nike-Zeus* guidance system. Others include Goodyear, Lear, RCA and Remington Rand.

Narmco, in its presentation to the San Diego authorities, indicated that its *Nike-Zeus* development could lead to a $20-million production contract. The company, presently employing 1000 persons at plants in La Mesa and Costa Mesa, expects its payroll to grow to 5000 in five years. That's why it wants to consolidate manufacturing facilities in San Diego. Its purchase involves 14½ acres, with an option for 10 more.

California missile interests are more concerned over some of the governmental problems at local levels than those on a national scale. Legislation introduced at the current session of the state legislature includes increases in income and corporation taxes, a higher minimum wage, liberalization of unemployment insurance and various other bills which will increase the cost of doing business and threaten to put companies located in the state at a competitive disadvantage with companies located where the business climate is more favorable. Significantly, a New Mexico legislator announced a plan to introduce legislation to wipe out income and corporation taxes in the hope of luring defense business from California.

A. C. Esenwein, new executive vice president of Convair and formerly general manager of its Fort Worth Division, points out that if the Russians fly a nuclear-powered aircraft this year—as forecast—it would probably be three or four years, at our present rate of progress, before the United States could duplicate the feat. "Our program for nuclear flight has been one of the most undulating series of circumstances I have witnessed," Esenwein observed. It would be possible, he added, to modify present aircraft, such as the Boeing B-52, Convair B-36 or Douglas C-133 for nuclear flight, but this would cost as much as building a totally new aircraft.

Lt. Gen. Jimmy Doolittle, new chairman of Space Technology Laboratories, describes space flight as an "extension of conventional aviation." And, apparently, the noise will be extended, too. In a recent paper, Al Mayo, Douglas-El Segundo's chief of equipment and safety research, observed: "Takeoff noises of space vehicles might nonetheless cause a degree of dissatisfaction to be expressed by people living in the immediate vicinity of the early space-exploration launch sites."

Lockheed's Missile and Space Division calls on the high-speed cameras used chiefly to photograph engineering test work to help solve maintenance problems when machines that need repair operate too fast for the eye to detect what's amiss. These cameras record 100 to 9000 frames a second and slow-motion playback works for the repair crews just as it does for the test engineers.

Quantities almost invariably come under the heading of classified information, so some of those attending the press showing on the *Thor* IRBM recently were surprised when they observed numbers conspicuously displayed on some of the units. No. 215 on a subassembly at Santa Monica, No. 198 on an assembled missile in the paint shop at the end of the final line, No. 141 on a test job on the launching pad at the Sacramento test facility. But Douglas missile people only grinned. The numbers, they declared, didn't mean a thing.

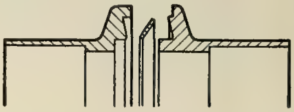
MARMAN

Engineering Notes

W. M. WILLIS

In looking at a finished product for the first time, one sees only the superficial aspects. At first glance it is difficult to visualize the intensive design effort, infinite refinements, and development engineering that have led to the final product.

The Marman Conoseal is a typical example, reflecting the reduction of theory by empirical testing to ultimate simplicity in finalized design. From this point of view, it may be interesting to discuss some of the details that make this joint outstanding, meeting the extreme requirements for advanced missile systems, aircraft, and the nuclear industry.



In the sketch above, note the reverse position of the gasket and pilot length which demonstrate that an incorrect assembly is impossible. This was attained by correlating the gasket proportionate requirements of performance to the length of the pilot for assembly.

For preassembly, the angle of the gasket had to accommodate ease of installation yet accomplish closed radial forces sufficient to produce plastic flow at the gasket edges to achieve a seal of zero leakage under the most severe environmental conditions. The reposed angle of flanges also has a definite design objective which allows for ease of joint disassembly subsequent to providing a radial seal.

The sharp corners on gaskets combined with material hardness and strength as differentiated from the flanges allow unlimited usage of flanges with new gaskets.

In order that the quality of the product be compatible with the performance of critical application areas, stringent quality control standards have been established for acceptance; 10% X-ray, 100% magnaflux, special forging temperatures which limit the grain size to a standard ASTM 5 to 6. One out of each heat batch of forgings is cut and severely etched, photomicrographed, and compared to the standard grain size. Vacuum melt or similar stock is specified to establish the dispersion of carbides into a very fine pepper pattern. This allows the customer, after welding flanges to this ducting system, to use the normal cleaning and pickling methods without destroying the surface.

The results of this five-year product development have culminated in coupled joints far exceeding the performance of bolted flanged per pound of weight.

Complete test reports are available upon request.

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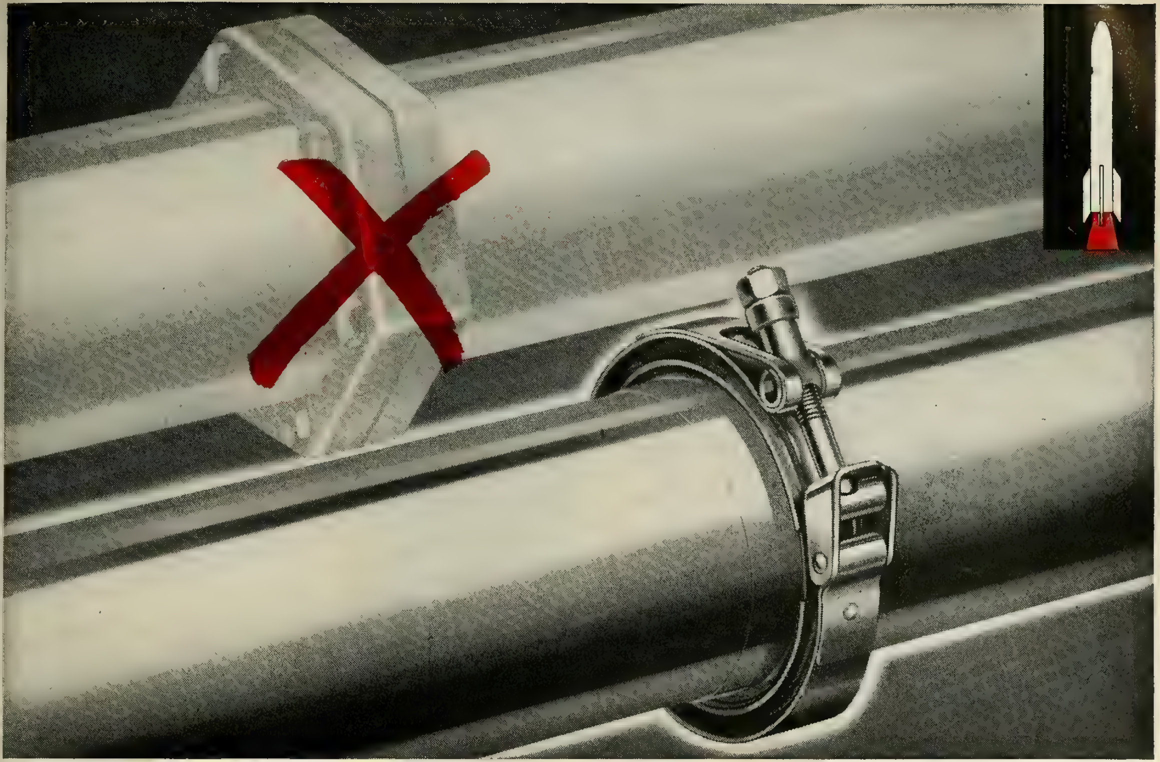

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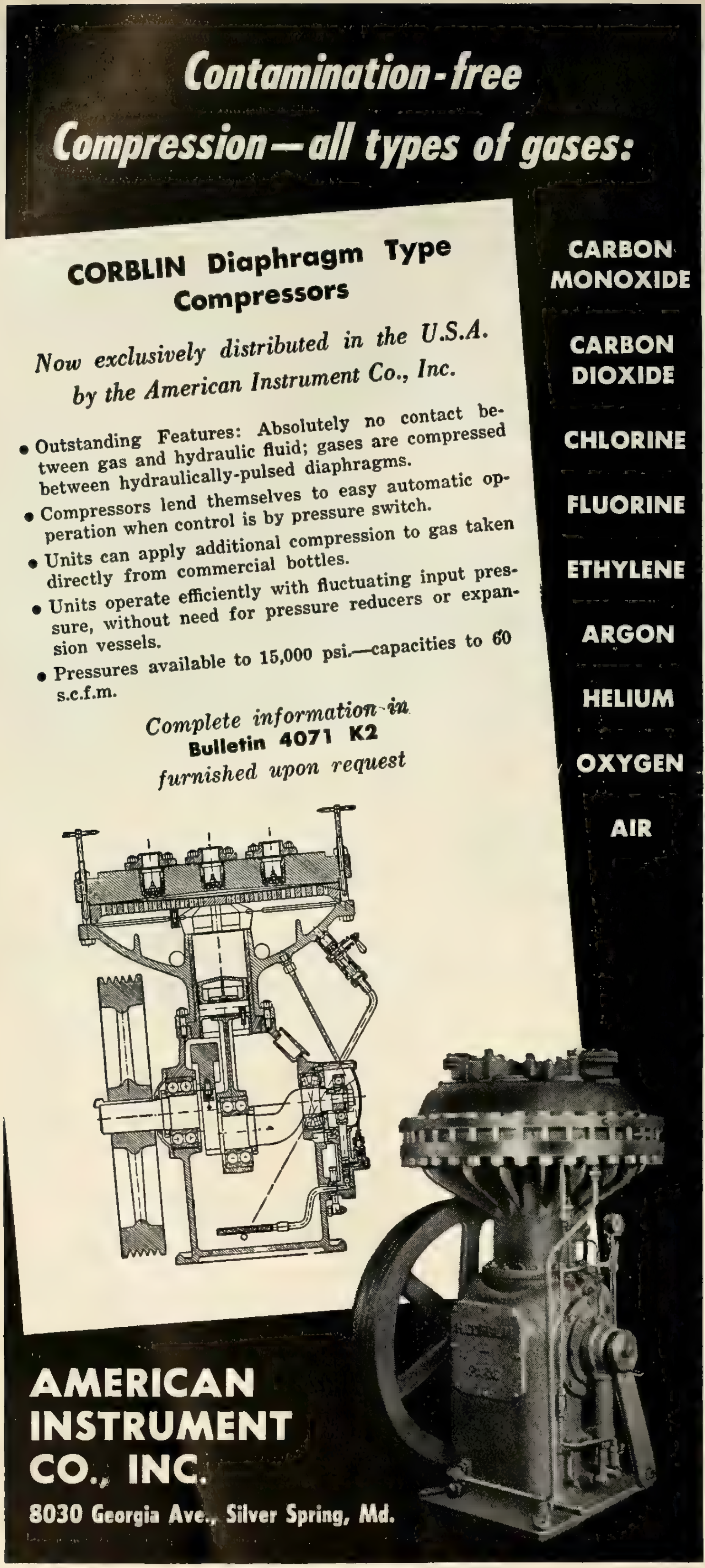

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when and where

FEBRUARY

Heat Transfer Div. of American Society of Mechanical Engineer Third Annual Symposium o Thermal Properties, Purdu University, Lafayette, Ind., Feb 23-26.

EIA Sixth Industrial Relations Conference, Chase-Park Plaza Hotel St. Louis, Feb. 25-27.

1959 Engineering Exposition, Balbo Park, San Diego. For information, contact exposition office a 422 Land Title Bldg., Sa Diego. Feb. 26-Mar. 1.

MARCH

IRE, AIEE and Association for Computing Machinery, 1959 Wester Joint Computer Conference Fairmont Hotel, San Francisco March 3-5.

Institute of the Aeronautical Sciences Flight Propulsion Meeting (classified), Hotel Carter, Cleveland March 5-6.

Second Western Space Conference and Exhibits, Great Western Exhibit center, Los Angeles, March 5-7.

Gas Turbine Division of the American Society of Mechanical Engineers, Turbine in Action, Cincinnati, March 8-11.

Third Annual Shock Tube Symposium, Old Point Comfort, Ft. Monroe, Va. For details: Armed Forces Special Weapons Center, Kirtland AFB, Albuquerque, N.M. Attn.: SWRS R. R. Birnkoff. March 10-11.

American Society for Metals, 11th Western Exposition and Congress, Pan-Pacific Auditorium and Ambassador Hotel, Los Angeles, March 16-20.

The American Rocket Society, 1959 Sectional Meeting, Daytona Plaza Hotel, Daytona Beach, Fla., March 23-25.

Institute of Radio Engineers, National Convention, Coliseum and Waldorf-Astoria Hotel, New York, March 23-26.

Society of the Plastics Industry, 16th Annual Conference, Pacific Coast Section, Hotel del Coronado, San Diego, March 25-27.

Society of Automotive Engineers, National Aeronautic Meeting, Hotel Commodore, New York, March 31-Apr. 3.

propulsion engineering

by Alfred J. Zaehringer

Ultimate chemical system, hydrogen and fluorine, may be near actual rocket use in the USSR. A recent Russian book on rocket fuels pictures a liquid rocket of 6.3-ft. diameter and about 46.5-ft. length (without payload package). Small upper oxidant tank indicates liquid fluorine and very large fuel tank below stores bulky liquid hydrogen. In fact, this "research rocket" is in the size category of the last stage of the *Sputnik* or *Lunik* rockets. Thrust is estimated at about 99,000 lb. All dimensions are compatible with H-F propellant systems. Puzzler is that hydrogen is shown as the coolant for a regenerative engine. It is known that at –181°C hydrogen has about 2.6 times the specific heat of water. If the Russians have learned to use liquid hydrogen as a coolant, it would be an accomplishment that the U.S. has not attempted.

Ejection of electrons from metals by bombardment of molecules moving at meteoric speeds is being studied by Soviet physicists. In an air stream moving at a speed of over six miles/sec., and colliding with iron, all air molecules are ionized. This phenomenon may be studied as a possible high altitude, high speed, satellite propulsion system.

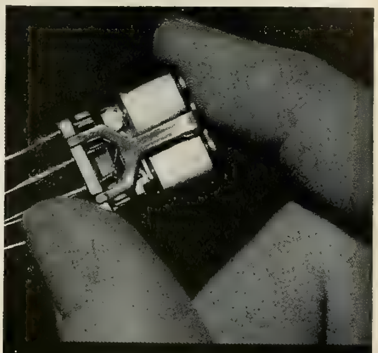
New boron fuel entry is the award of a $2-million Air Force contract to Stauffer-Aerojet. Facility is to be located at Aerojet's Sacramento facility. It will be a pilot plant with boron fuel capacity estimated at about 1½ tons per month. The Stauffer-Aerojet fuel is said to be less costly than either the Callery or Olin Mathieson fuel. Speculation is that some of the new fuels will be suitable for rocket propulsion. At any rate, it looks like a boron battle will begin to brew.

Solid propellant battle may also be shaping up. Hercules Powder (operator of Allegany Ballistics Lab) says that it has plunked $5 million into its Bacchus, Utah, solid facility; employment there is expected to go up to an eventual 3000. Propellant testing, possibly for Air Force *Minuteman* project, is starting. Previous reports stated that Hercules had joined hands with the Naval Propellant Plant for work on *Minuteman.* Right now, Thiokol and Aerojet have major solid propellant work on the solid ICBM. A few days ago, Standard Oil Company of Indiana was awarded a R&D contract for work on a solid propellant auxiliary power system for *Minuteman.*

Perchlorates for propellants are perking. Sodium chlorate, basic intermediate for present ammonium perchlorate processes, is now being pushed by three firms. American Potash & Chemical will produce some 15,000 tons per year of sodium chlorate at its $4.3-million plant at Aberdeen, Miss. Hooker Chemical's HEF subsidiary will complete its AP-LP plant at Columbus, Miss. Pennsalt is pushing its AP production at its Tacoma, Wash. plant. All in all, 1959 may see plenty of perchlorates available for the solid propellant people. Though overall AP production may double or triple, not much price change is expected. Until *Minuteman's* production is in the thousands, AP production will be relatively small compared to the high volume liquids such as LOX.

Other solid developments: Thiokol will add a quarter million dollar propellant development lab to its Brigham, Utah, facility. The Naval Propellant plant at Indian Head, Md., starts delivering solid rocket motors for the Martin-designed and developed *Bullpup* missile. Allegany Ballistics Lab did the design work on the rocket motors; initial deliveries will mean beginning of fleet evaluation for the bird.

IN THIS SUB-MINIATURE RELAY



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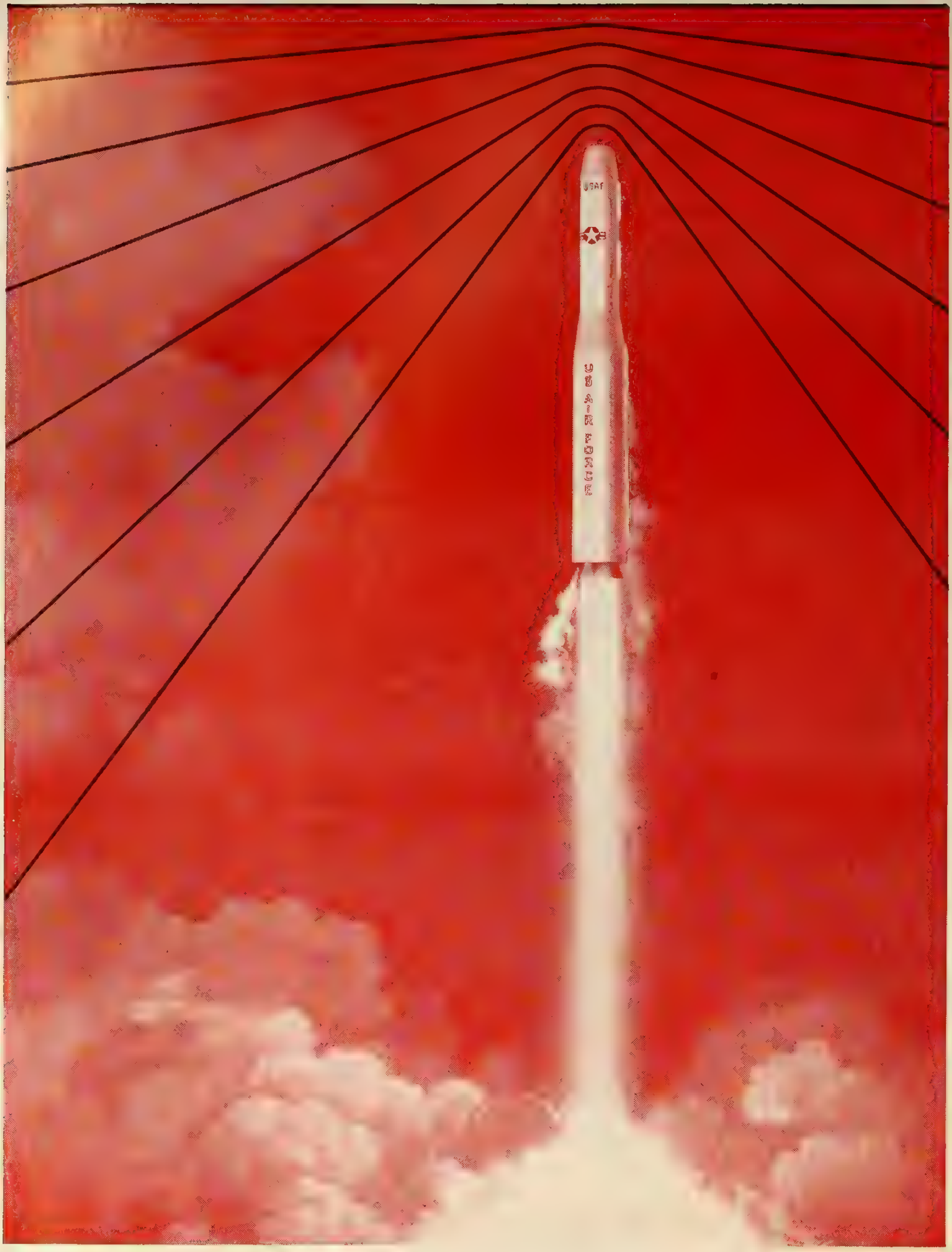

Titan nose cone from Avco—The recent flight of the Air Force Titan ICBM was achieved by the free world's most advanced rocket technologists. Avco scientists and engineers, pioneers in missile reentry work, are members of the Titan team. They are contributing a reentry vehicle designed to withstand the scorching friction during the reentry phase of the ICBM's planned intercontinental range flight. And now, Avco has been chosen as the associate contractor for the reentry vehicle of the next Air Force ICBM . . . the mighty, solid-fueled Minuteman.

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missile people

The University of Cincinnati has named the "fastest man on earth," **Col. John P. Stapp,** as part-time associate professor of industrial medicine. He will work with graduate students and physicians on the effects of velocity on the human organism.

Stapp, who is with the Air Research and Development Center at Wright-Patterson AFB, Dayton, Ohio, is noted for his research on the effects of acceleration and deceleration on man. He won the "fastest man" title in one of his rocket sled experiments when he was accelerated to 632 miles an hour in five seconds, then halted in one second.

W. H. Jaeger has been appointed as North American Aviation's corporate engineering and planning representative at Huntsville, for liaison with Headquarters, Army Ordnance Missile Command. Previously he was plant engineer at Rocketdyne's Neosho, Mo., *Jupiter* engine factory.

Tom Courtney, formerly chief project engineer, has been named program director for the *Corvus* air-to-surface missile system being developed by Temco Aircraft Corp. Courtney came to Temco last year from McDonnell Aircraft Corporation, St. Louis, where he was program manager for the *Green Quail* missile.

Dr. Norman F. Jacobson will head the newly-formed Reliability Section at California Institute of Technology's Jet Propulsion Laboratory. The section is charged with providing safeguards against environmental changes and establishing required reliability tests. Jacobson, 30, has been with JPL since 1956 and was responsible for "payload reliability" in connection with the building and launching of the *Explorer* satellites and the *Sergeant* weapons system.

Dr. Douglas Duke, formerly head scientist of the satellite tracking project *(Spacetrack)* at AFMTC, has joined Radiation, Inc. as a technical advisor in space technology. He has worked on various space projects with Convair Astronautics and the Navy Electronics Laboratory.

General Electric's Semiconductor Products Department has established a Rectifier Product Section with **C. Graydon Lloyd** as general manager. GE said the reorganization was necessitated by the department's expanding activities in the semiconductor components field. Lloyd was formerly manager of engineering for the Technical Products Department and general manager of General Electrics' Specialty Electronic Components Department in Auburn.

Another GE department, Heavy Military Electronics, has set up two new marketing units—Defense Industries Sales and Defense Industries Contract Administration—to serve the defense prime contractor market. **George D. Prestwich** was named manager of Defense Industries Sales, and **Fred Glickman** will head Defense Industries Contract Administration. The company said the new units would make available to major defense prime contractors technical know-how and facilities for designing and producing large, complex electronic subsystems.

Richard E. Roberts has been named chief of GE's newly-organized Instrumentation and Communication unit, part of the company's Missile and Space Vehicle Department.

G. W. Trichel has been appointed military advisor to **T. F. Morrow,** group vice president-defense and special products, Chrysler Corp. Trichel has been president of Chrysler's Amplex Division since 1956.

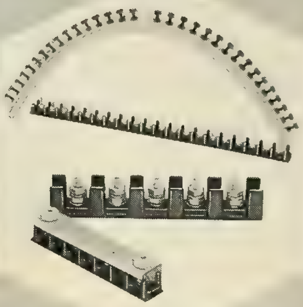
Beckman's Systems Division has organized a new Military Electronics Department to operate within the Systems Division. This group will be under the direction of **Kenneth F. Miller,** formerly with the Contract and Engineering Department of Beckman's Heliport Division.

Cook Electric Co. has named two new associate directors of its Research Laboratories Division: **Raymond O. Fredette** and **Alton D. Anderson.** Fredette formerly was assistant director of the laboratories and, as staff engineer and chief aerodynamicist, directed development of systems for recovering ballistic missile nose cones and recovering man from early space trips. Anderson, previously Lab assistant director, chief engineer and director of Cook's Systems Development Section, has worked on missile instrumentation and mine countermeasures systems.

Former general manager of IBM's Data Processing Division, **Charles J. Lawson, Jr.,** has been promoted to assistant director of manufacturing services. His duties include providing technical counsel to operating division managers. Lawson's successor as head of the Rochester plant is **Clarence E. Frizzell,** who was assistant general manager of IBM's San Jose, Calif., plant.

Borg-Warner Corp. has named **Tom G. Conway** vice president in charge of manufacturing of its Pesco Products Division. He will supervise the fabrication of aircraft and missile components.

olympic terminal strips



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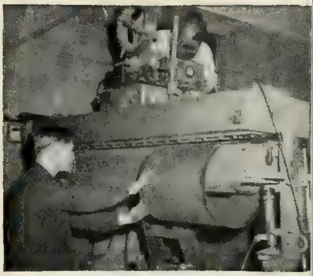

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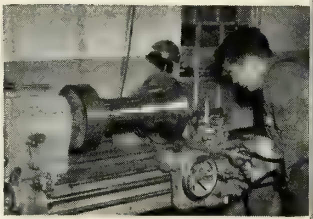
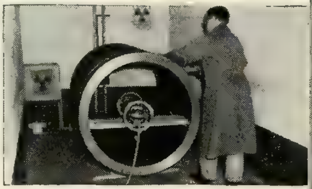
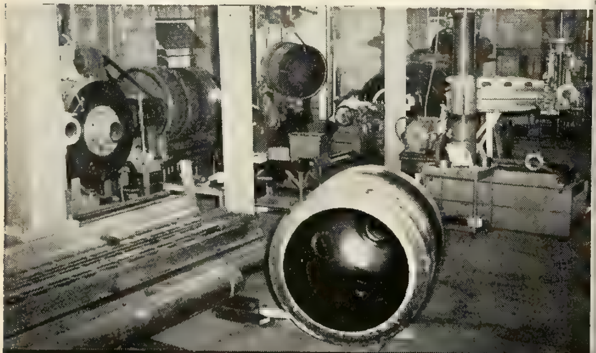


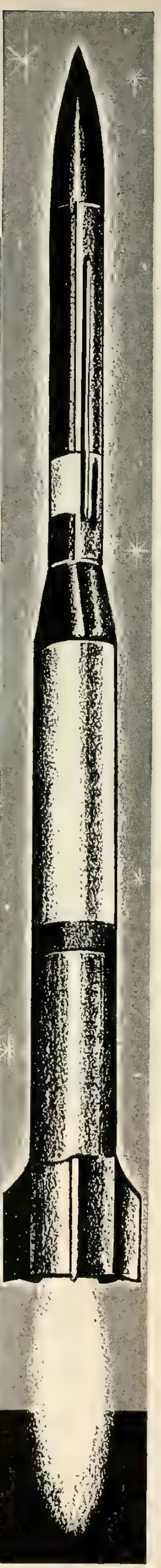
Machining Nozzles



X-Ray Inspection

Below: Machining Motor Cases





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Fuels Vaporization Study Contract Awarded by NSF

WASHINGTON—Formulation of an overall theory of the atomization and vaporization of liquid fuels in continuous-flow heterogeneous combustion systems will be attempted by three engineers of the University of Wisconsin's department of mechanical engineering.

Under a grant of $57,600 from the National Science Foundation, the engineers will utilize a photographic technique to study vaporization in the simulated combustion chambers of rockets, ramjets and turbojet power plants.

The engineers, Profs. Phillip S. Myers, Otto A. Uyehara and M. M. El-Wakil, say present design approaches are based largely on trial-and-error. This applies to liquid fuel combustion chambers for both ramjets and reciprocating engines.

They point to the ever-increasing requirements for speed and power in propulsion and the need for development of a scientific basis for designs that will permit optimum efficiency.

The Foundation financed an earlier research project by the same engineers to develop a photographic technique which will be used in the new study. It is carried out by mixing fluorescent dyes with the fuel droplets to make them primary light sources under high-intensity light. Photographs of the vaporization taken in this way are sharper and do not have the defects encountered in other methods.

The engineers hope to test many different fuels under varying conditions. including some new high energy fuels, possibly flourine.

Digitronics Corp. Sells Two Component Divisions

WASHINGTON—The National Aeronautics and Space Administration has announced the appointment of Robert R. Gilruth as Director of Project *Mercury*'s Space Task Group.

Assistant Director of the Group is Charles J. Donlan and Special Assistant to the Director is Paul E. Purser, according to the NASA announcement.

Charles W. Mathews, NASA said, will be director of the Operations Division of the Task Group; Maxine A. Faget, director of the Flight Systems Division; and Charles H. Zimmerman, director of the Engineering and Contract Administration Division.

The Task Group's headquarters will be at NASA's research center at Langley AFB, Va.

book reviews

THE ATOM AND THE ENERGY REVOLUTION, by Norman Lansdell, Philosophical Library, Inc., New York, 1958, 200 pp., $6.

This work is a study of the profound implications that atomic energy has for the world of tomorrow.

The military and economic applications of atomic energy are already being developed. But little has been written about the probable affects of the atomic era on the whole of human life and society. What will be its effect, for instance, on world trade, the relation of industry to the state, and on national sovereignty?

Lansdell's work is for the general reader who wishes to grasp the social and political implications of the atomic era, for the businessman who must adapt himself to the new economy, or for the specialist in any related field of inquiry. The book covers the potential uses to which the atom may be put; its exploitation by separate countries and by international bodies; and its impact upon the world.

PHYSICAL LAWS AND EFFECTS by C. Frank Hix, Jr., and Robert P. Alley; John Wiley & Sons, Inc., New York, 1958, 291 pp., $7.95.

A good compilation, arranged in three cross-reference systems, of complete and convenient information on physical laws, both common and uncommon.

It is valuable as a quick reference for experienced engineers and scientists because each item is comprehensive, including further references to be consulted if necessary.

The book is arranged alphabetically by the names of the laws, alphabetically by the physical quantities involved and alphabetically by fields of science. The format includes a short description of each law, an illustration, an indication of the expected magnitude, and a list of references.

Highly recommended for use by anyone dealing with physical laws.

COMPACT HEAT EXCHANGERS, by W. M. Kays and A. L. London, McGraw-Hill Book Co., New York, 1958, 156 pp., $6.00.

This work covers all types of heat exchangers in use today, including tube banks; plate-fin surfaces; finned tube surfaces; and screen and sphere matrix surfaces.

Basic heat transfer and flow friction data are presented for a total of 88 surface configurations. The book makes available to designers the results of experimental and analytical work on compact heat-transfer surfaces.

One objective of the authors is "to give a common treatment to all surfaces considered, thus avoiding the confusion so often encountered with a large number of arbitrarily defined parameters."

RADIOACTIVITY MEASURING INSTRUMENTS, by M. C. Nokes, Philosophical Library, New York, N.Y., 1958, 75 pp., $4.75.

A well-written work giving detailed instructions for making a number of simple radioactivity measuring instruments. The author, now with the Isotope Division, Atomic Energy Research Establishment, Harwell, England, was formerly Senior Science Master at Harrow School.

In the book's nine chapters, he covers Geiger-Müller counters and the phenomena in G-M tubes, various trigger devices, power supplies, rate meters, scalers, instruments and practical hints for constructing a measuring instrument.

One minor drawback: The author gives some idea of the cost of parts involved in building a radioactivity measuring device, but, despite the fact that American marketing for the book was arranged, prices are given only by the English currency standard.

EFFECT OF SURFACE ON THE BEHAVIOUR OF METALS; Institute of Metallurgists, 100 pp., $10, Philosophical Library, New York.

A series of lectures delivered at the Institution of Metallurgists Refresher Course, 1957. Embodies the four papers presented during the series and covers topics of: Methods of Preparation and Examination of Surfaces; Influence of Surface Treatments on the Chemical Behavior of Metals; Relationship between Surface Condition, Friction and Wear; Influence of Surface on the Physical Properties of metals.

Included are 30 diagrams in the text and 10 pages of art plates.

Fast Write-Offs

WASHINGTON—Office of Civil Defense Mobilization has granted five concerns fast amortization permits for tax purposes on expansion of missile and electronics research. Firms include: Hercules Powder, Motorola, Inc., Bendix Aviation Corp., Lockheed Aircraft Corp., and Sundstrand Machine Tool Co.

Hercules was allowed fast depreciation on 65% of the $4,602,250 expansion cost of a solid propellant research facility at Bacchus, Utah. The cost of expansion for the other firms was under $1 million each.

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NEW PRODUCT BRIEFS

ING MOTORS—A new line of ex- ıely thin synchronous timing motors 25, 50, or 60 cycle operation in five dard voltage ratings has been pro- ed by A. W. Haydon Corp. Main ures are extremely thin design with lable torque equivalent to much ker motors, and completely electrical ration. Only 7/8" thick, these units designed to occupy considerably space than other available motors. r design has completely eliminated need for mechanical devices to con- the direction of rotation of the or. Although mechanical devices been used in the industry for years, have many troublesome disad- ages such as being noisy and offer- only limited life. Over 125 standard ut speeds from 300 R.P.M. down to revolution in six hours can be sup- d with either standard or heavy duty trains. With a nominal 30 oz-in ing torque at 1 R.P.M., these ors can be used in a wide variety of ications. Bulletin AWH MO-806 il- ates the motor, contains outline and nting dimensions, charts, applicable ary specifications and completely ribes these motors.

No. 241 on Subscriber Service Card.

VEGUIDE SWITCH—The "Delta" o-miniature waveguide switch, fea- g extreme compactness and light- —0.37 lbs.—has been developed by -Lan Electronics Co. Designed for "X" band—81.2 to 12.0 KMC—the ta" waveguide switch is remotely rolled to provide a highly reliable ns of switching a single waveguide t to either of two outputs. RF hing under power, with a maximum S/R of 2.1/1.0 during the switching , and 1.1/1.0 in either position over entire frequency range is achieved he unique design. RF power rating he unit is equal to associated wave- e. Other features of the Delta micro- ature waveguide switch include hing time of only .007 seconds and tion of 50 db down minimum. The is priced at $285, with quantity s available.

No. 244 on Subscriber Service Card.

CUIT BREAKER. The Klixon D6760-5 naltype, three-phase circuit breaker, w model in the Klixon D6760 series pplications on aircraft and missile ground support equipment where high voltage power is used, has been produced by Metals and Controls Corp. The –5 version is a modification of the basic design with greater electrical clearance between phases. The manufacturer says this internal redesign eliminates the possibility of arcing between phases on short circuit interruption.

Circle No. 240 on Subscriber Service Card.

QUARTZ CLOCK. A quartz clock, which can be used both as a timekeeper (rate variation less than 1/100th of a second per day) and as a reliable frequency standard, has been made available by the Freeport Engineering Co. Manufactured by the Oscilloquartz Department of Ebauches S.A., Neuchatel, Switzerland, the B-288 quartz clock consists of six standard units mounted on slides in a sturdy metal case only 18" x 18" x 15". Compact and portable, the B-288 quartz clock is an exceptionally reliable frequency standard, Freeport says. It generates frequencies of 100 kc, 10 kc, 200 cps, 60 cps, and 50 cps, which can be distributed throughout af buolding without further amplification.

Circle No. 243 on Subscriber Service Card.

URETHANE FOAM PROTECTION. Sensitive recording instruments carried in the nose cones of Thor and Atlas missiles are being packaged in urethane foam produced by DuPont. The sphere of foam, no larger than an oversized basketball, withstands impacts up to 45,000 times that caused by the force of gravity, DuPont says, and protects the equipment from vibration and shock from the launching to the time it is ejected and returned to earth. This cocoon of urethane foam consists of an outer shell of hard foam (20-lb density) containing a core of soft foam (6-lb. density) in which are embedded the recording devices.

Circle No. 245 on Subscriber Service Card.

RECORDER. An analog & operations recorder, developed to military requirements and specification has been developed by Brush Instruments, division of Clevite Corp. According to Brush, the new recorder permits simultaneous recordings of two types: analog recording of the dc to 100 cps range.

Circle No. 242 on Subscriber Service Card.

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MISSILE LITERATURE

MICRO VOLT AMMETER. A bulletin released by the Keithley Instruments, Inc. describes the Model 150 micro volt-ammeter for measuring voltages as low as 0.03 microvolts and currents down to two micro-microamperes. The four-page bulletin gives a detailed description including circuit design considerations, schematic diagram and actual reproductions of stability performance tests. Also included are specifications, prices and ordering information.

Circle No. 200 on Subscriber Service Card.

CORROSION PREVENTION. A bulletin describing techniques developed through use of treated pure metals which are firmly bonded to a steel base by metallizing has been released by the Metallizing Engineering Co. These metal coatings assure protection against oxidation for 25 to 50 or even 100 years. In addition to describing the systems, the new bulletin pictures some typical applications on a broad range of equipment and structures.

Circle No. 201 on Subscriber Service Card.

CIRCUITRY. A new booklet entitled "Notes on Transistor Switching Circuitry" is available from Navigation Computer Corp. The 16-page pamphlet covers the field of transistorized pulse handling techniques, and includes diagrams for programing pulses, delays, serial-to-parallel conversion (and vice-versa), ring counters, cycle distributors, binary counting, electronic switching, etc.

Circle No. 202 on Subscriber Service Card.

TESTING DELAY LINES. A 35-page Mimeographed Manual on "Procedures For Testing Ultrasonic Delay Lines" is available from the Arenberg Ultrasonic Laboratory, Inc. The manual covers basic inspection, single-terminal impedance measurements, overall insertion loss, band width, ripples in the band pass, secondary signals, multiple travel signals, direct feedthrough, sum of secondaries, delay time, absorption in medium, temperature effects and other variables, such as military requirements. Applications to high speed computers, radar MTI and integration kits, as well as timing devices are considered. The techniques discussed will have bearing on all ultrasonic measurements.

Circle No. 203 on Subscriber Service Card.

TEFLON TUBING. A Bulletin on the CDF line of flexible thin-wall paste-extruded tubing and spaghetti-extruded Teflon is available from Continental-Diamond Fibre Corp. Complete tables of sizes and tolerances are given. This 4-page, 2-color brochure also presents in tabular form lists of electrical and physical properties of the tubing. The test method is indicated for each property.

Circle No. 204 on Subscriber Service Card.

BROCHURE. Space Electronics Corp. has released a brochure describing its facilities and capabilities in electronics techniques for missile guidance, control, instrumentation and communication, and ground support equipment. Accent is placed on R&D operations.

Circle No. 212 on Subscriber Service Card.

PRODUCTS. Eastern Industries, Inc. has released a brochure describing its products for manned aircraft and missiles, including pumps and hydraulic power units, pressurization-dehydration units, electronic liquid cooling, and
frigeration-type cooling packs, se
valves and servo systems. Perform
specifications, weights and dimen
and power requirements are g
along with tables, graphs, and illu
tions.

Circle No. 205 on Subscriber Service C

TAPE RECORDERS. A new treatise
cussing the fundamentals and chief
plications of magnetic instrumenta
recording is available from An
Corp. From the introduction of n
netic recording devices in this cou
some 16 years ago, the booklet tr
the need for more precise meas
ment, and points out how magn
tape devices are suited to meet
The booklet includes discussion of
principles of magnetic recording,
physical elements of instrumentation
corders, and the four major recor
processes—direct, frequency mod
tion, pulse-duration modulation,
digital.

Circle No. 206 on Subscriber Service C

TUBE HANDBOOK. A 550-page T
nician's Handbook describes over I
receiving tubes and 330 picture t
as well as data on transistors, cr
diodes, and special-purpose tubes,
duced by the Hytron Division of
Columbia Broadcasting System.

Circle No. 207 on Subscriber Service C

MECHANICAL FILTERS. A 16-p
illustrated catalog describing the c
plete line of standard production Co
Mechanical Filters has been issued
Collins Radio Co.

Circle No. 211 on Subscriber Service C

TECHNICAL ARTICLES. Articles of
terest to engineers, designers and t
nical personnel concerned with s
wich construction, adhesive bonding
structural plastics are now avail
without charge in the bimon
Narmco Engineering Topics.

Circle No. 208 on Subscriber Service C

NEW MANOMETERS. A cata
recently made available by Trim
Instrument Co. illustrates and descri
two manometers of new design.
company says the new units are
precented in their accuracy. Designa
Models C-22 and C-12, their dram
exterior design is highlighted by
black scale with white numerals
increments. Cases of both are of
truded aluminum with gold anodi
finish. Their wells differ—Model C
is a normal well type, while Mo
C-12 is a raised well type. Operat
data are identical, with maximum op
ating pressures of 400 psig and ran
from 12 to 120 inches.

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strain when plugged in the appropri
transducer or strain gauge, accord
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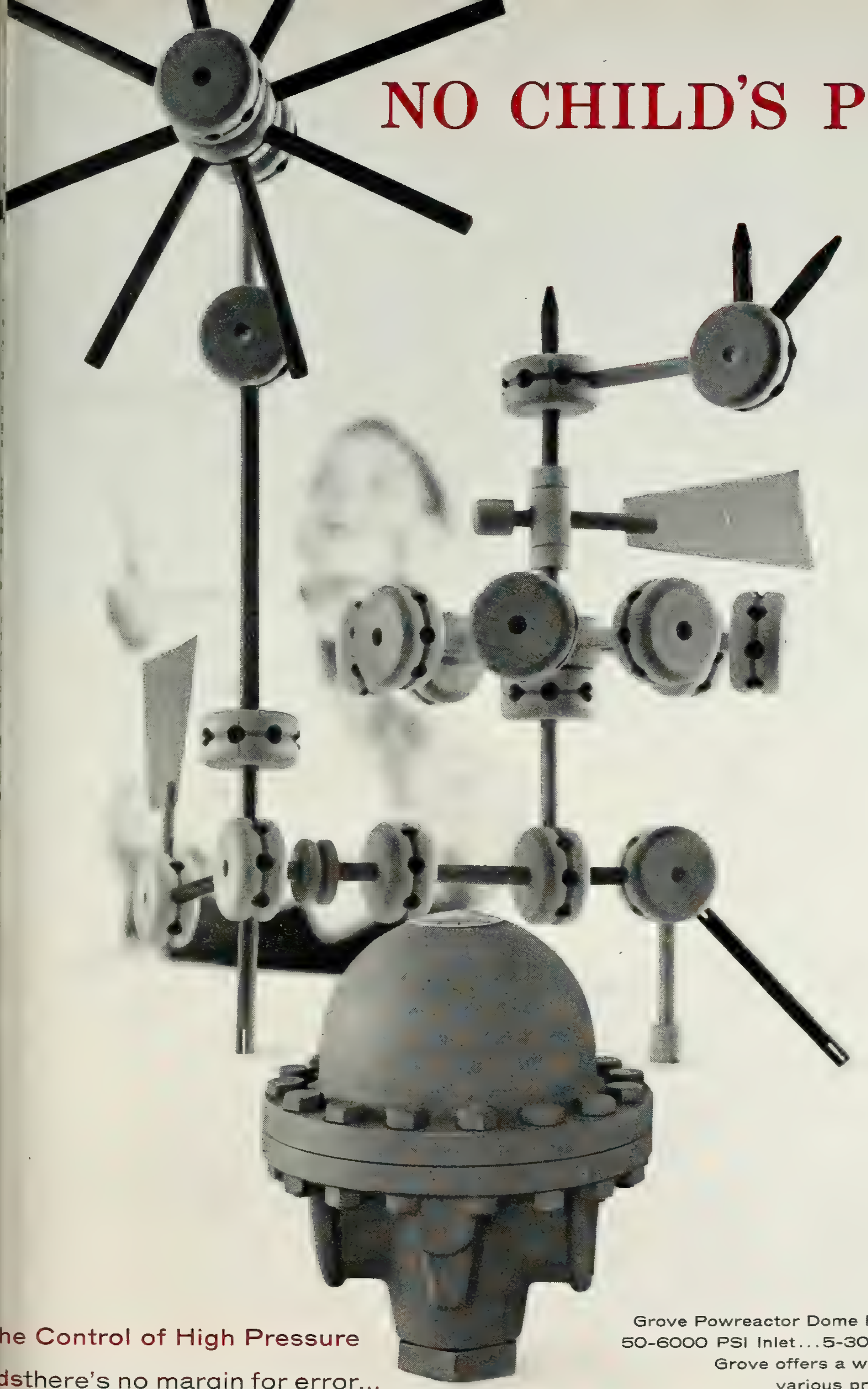

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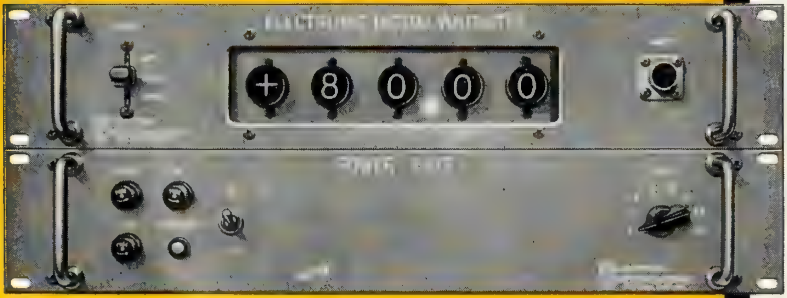

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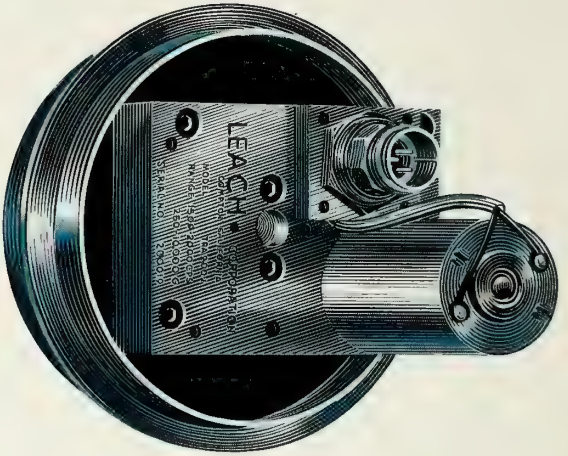

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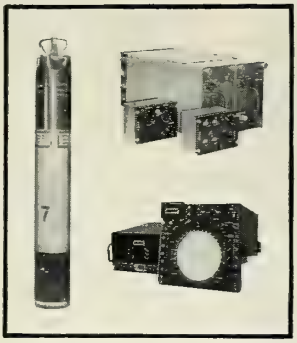

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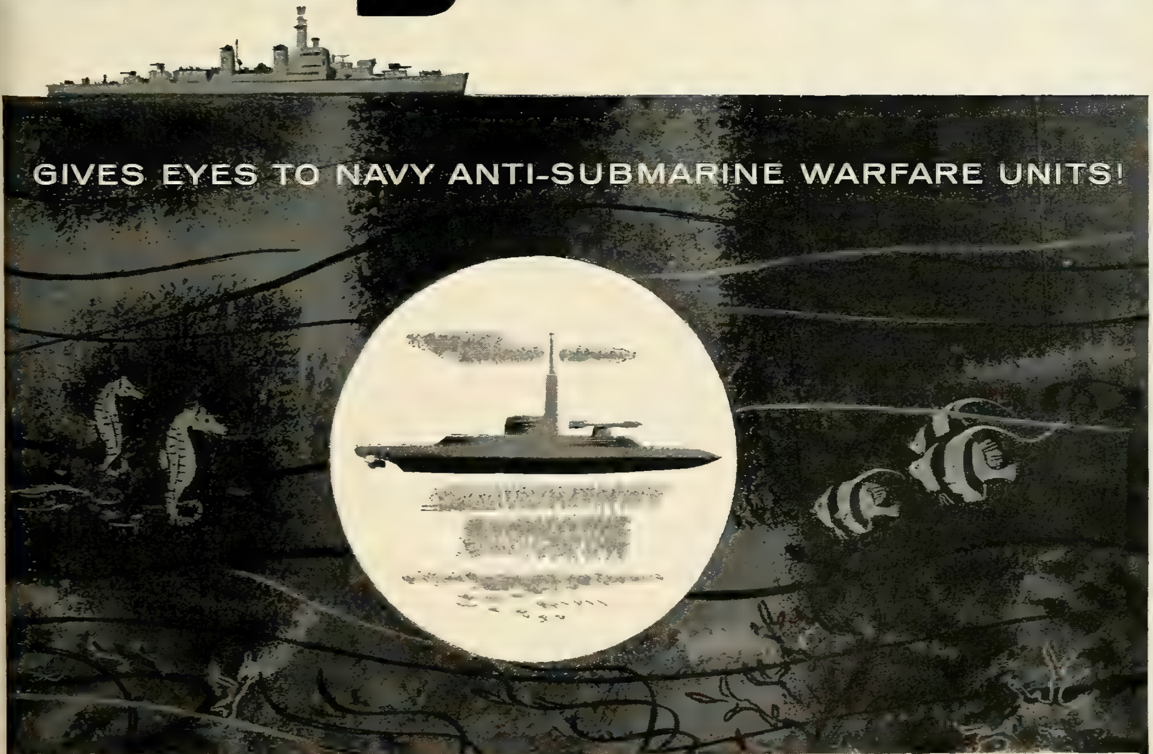
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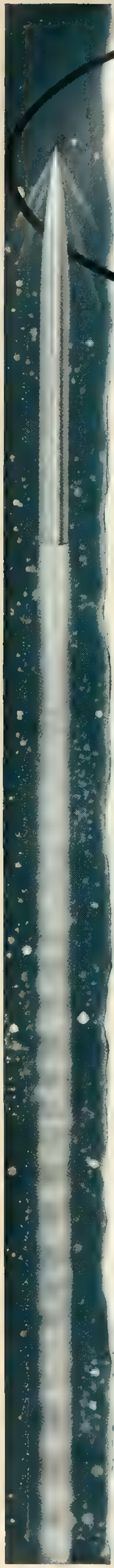

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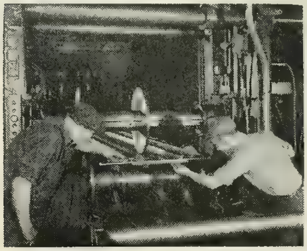
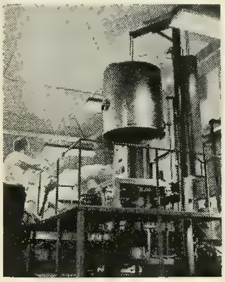
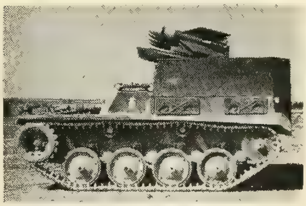
COVER: Armstrong-Siddeley gamma rocket engines are powerplant for *Black Knight* (p. 31).



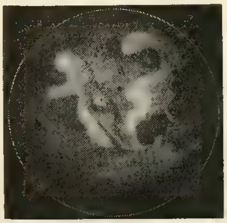
ALCOA 14,000 ton press provides aluminum extrusions—some 20 ft. long—for *Titan* tanks and outer skin.



SINGER's cast epoxy mirror is a new milestone in reflective optical components (p. 16).

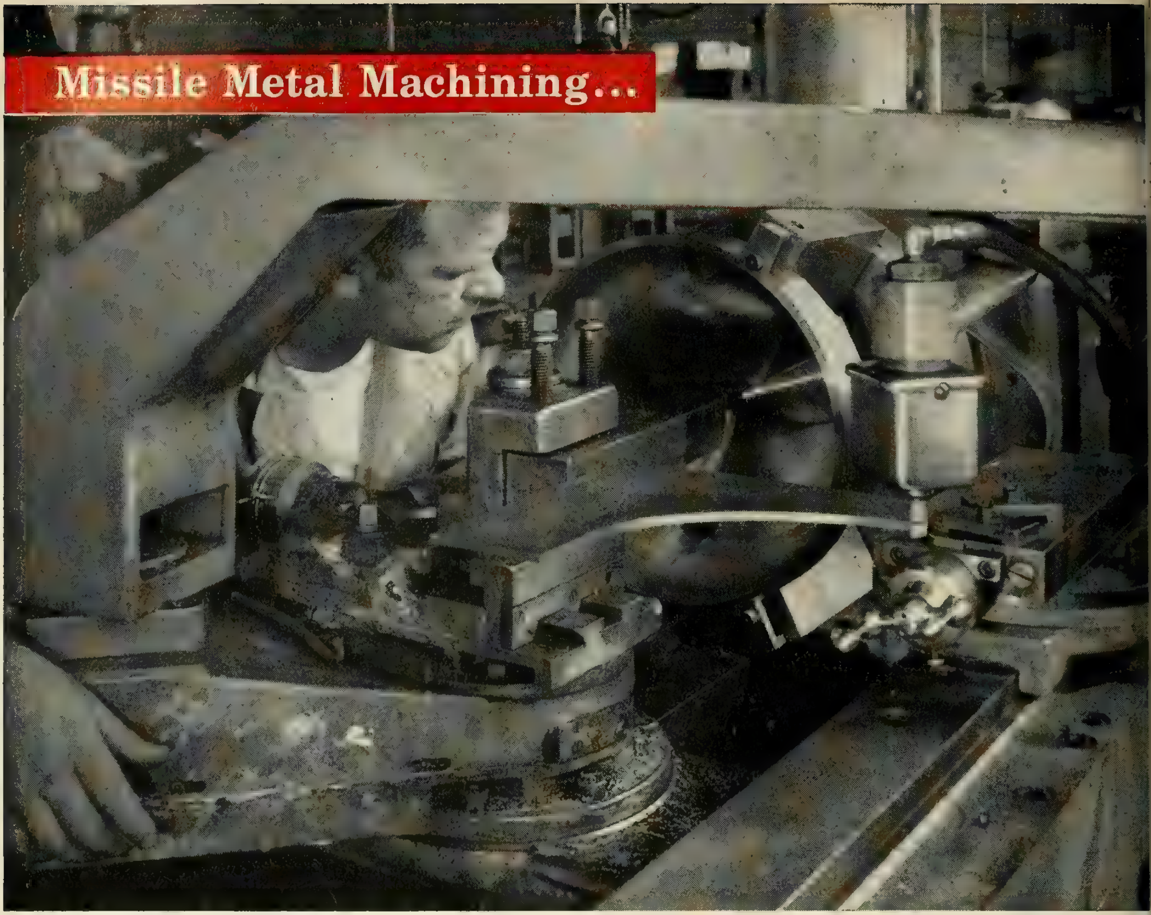


NORD-AVIATION's *SS-10* and *SS-11* anti-tank missile may be supplied to U.S. forces in Europe (p. 32).



NEW WEATHER Bureau section will work with NASA in meteorological research with rockets and satelliites (p. 17).

Missile Metal Machining...



FROM BLANKS TO BULKHEADS!

The Diversey craftsmen above is machining the inner diameter of a Forward Bulkhead of the Hawk missile to a fine 63 microinch finish. Notice the precision curved template in the center of the picture with the follower at the right end transferring the contour to the interior of the bulkhead. Another good example of the famous air gage tracer lathe technique that has brought the missile hardware field to such an advanced state.

Diversey starts with blank forgings. Using their remarkable ability to integrate hydrospinning and contour turning techniques Diversey craftsmen are able to produce the finest and most precise missile and rocket hardware components.

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HYDROSPINNING NOW AVAILABLE

Diversey announces the formation of a new Hydrospinning Division with the acquisition of new Hydrospin equipment up to 42" capacity.

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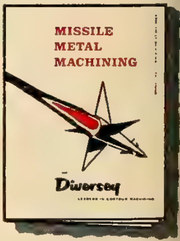

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FROM NOSE TO NOZZLE, FROM FIN TO FIN, CONTOUR TURNED PARTS—WITH PRECISION BUILT I

The Neglected Atomic Propulsion Program

It is a sad and obvious fact that the nation's progress in producing an atomic-powered aircraft or a nuclear rocket engine is not as good as it either could or should be.

The present status of both the nuclear plane, which would be a missile launching platform, and the nuclear rocket engine are treated in the 25th semi-annual report of the Atomic Energy Commission for July-December, 1958.

Of the Nuclear Propulsion for Manned Aircraft, it says:

"Investigations were continued on two basic systems, the direct-cycle and the indirect-cycle.

"General Electric Co., Evendale, Ohio, is under contract to develop reactors for the direct cycle system.

"Pratt and Whitney will perform research and development leading to indirect-cycle reactors for aircraft propulsion."

The report continued that:

At the National Reactor Testing Station, Idaho, the core test facility is being used to experiment with a second reactor core in which materials with higher performance capabilities are used; and construction is essentially completed on R&D facilities at the Connecticut Aircraft Nuclear Engine Laboratory of P&W; and the design of a Shield Test Air Facility was started in June for construction at the National Reactor Testing Station, with completion due in June, 1960.

Further, the report said that the ANP research and development effort had successfully passed many important technical milestones, including the operation of turbojet engines in parallel from a common heat source; the completion of 47 flights in a one-megawatt reactor in a nuclear test airplane outfitted with a complete crew shield; and the accumulation of thousands of hours of irradiation testing of aircraft materials, components and subsystems.

The Nuclear Propulsion for Unmanned Vehicles in the report is divided into three parts.

In nuclear rocket propulsion (*Rover*) the program to demonstrate the feasibility of nuclear rockets continued at the Los Alamos Scientific Laboratory, the major effort being devoted to development and fabrication of an initial test device, *Kiwi-A*. This is a relatively lower power experimental reactor using solid fuel elements and a gaseous propellant.

The nuclear ramjet propulsion program (*Pluto*) to demonstrate the feasibility of a high temperature air-cooled reactor for ramjets was continued by the University of California Lawrence Radiation Laboratory at Livermore. North American Aviation Inc. is working on materials. Design and development continued on *Tory II*, a small-scale non-flyable reactor to be constructed at the Nevada Test Site.

In systems for nuclear auxiliary power (*Snap*), two basic approaches are being followed for space purposes. The first (*Snap 1*) is being developed by the Martin Company, Baltimore, to use the heat from a radioactive isotope to operate electrical power conversion equipment. The second (*Snap 2*) is an Atomics International contract to use a nuclear reactor as a heat source to operate a generator. Work on a test facility at Santa Susana, Calif., has begun.

The above is not so important for what it says as for what it does not. The AEC has never been notorious for releasing information. But on the other hand neither has it been reticent about accomplishment in its field—for which it is the sole releasing agency. To both subjects—nuclear aircraft and nuclear rocket—the reports devote a little more than two pages. And, judged by a factor of accomplishment, it doesn't seem to rate more.

Whether it is lack of money or lack of recognition, the fact remains that the overall aerial nuclear propulsion project—including reactor, engine, shield and vehicle—which began in 1946 has since died and had rebirth, been strangled, kicked, starved, beaten and neglected. More than a dozen committees have charted its program, usually in different directions. Project officers in the program have been transferred, promoted and died during its 13-year meandering course. One of these said recently—and wearily:

"It isn't so much a matter of money as of interference and vacillation. The project is extremely complex and difficult. Thus far no one group has ever lasted long enough or been let alone long enough to encompass all its details. One and perhaps the only solution is to give the project to one agency and only one—and then to protect it from interference on all sides."

Clarke Newlon

NOTABLE ACHIEVEMENTS AT JPL...

PIONEERING IN SPACE RESEARCH

Another important advance in man's knowledge of outer space was provided by Pioneer III. This, like many others of a continuing series of space probes, was designed and launched by Jet Propulsion Laboratory for the National Aeronautics and Space Administration. JPL is administered by the California Institute of Technology for NASA.

During its flight of 38 hours, Pioneer III was tracked by JPL tracking stations for 25 hours, the maximum time it was above the horizon for these stations.

The primary scientific experiment was the measurement of the radiation environment at distances far from the Earth and telemetering data of fundamental scientific value was recorded for 22 hours. Analysis of this data revealed, at 10,000 miles from the Earth, the existence of a belt of high radiation intensity greater than that observed by the Explorer satellites.

This discovery is of vital importance as it poses new problems affecting the dispatch of future vehicles into space. The study and solution of such problems compose a large part of the research and development programs now in extensive operation at the Laboratory.

jpl

CALIFORNIA INSTITUTE OF TECHNOLOGY
JET PROPULSION LABORATORY
A Research Facility operated for the National Aeronautics and Space Administration
PASADENA, CALIFORNIA

OPPORTUNITIES NOW OPEN IN THESE CLASSIFICATIONS ▶ APPLIED MATHEMATICIANS . ENGINEERING PHYSICISTS . COMPUTER ANALYSTS . IBM-704 PROGRAMMERS AERONAUTICAL ENGINEERS . RESEARCH ANALYSTS . DESIGN ENGINEERS . STRUCTURES AND DEVELOPMENT ENGINEERS

washington countdown

Capitol Hill heat . . . over DOD's missile program grew white hot last week when DOD's planned programmed obligations for FY 1959-60 revealed that $400 million less has been obligated for missiles in FY 1960 than was obligated in FY 1959. DOD plans to obligate $6.817 billion in FY 1960 for missiles, compared to $7.212 billion in FY 1959. ICBM and IRBM planned obligations account for about 30%. In FY 1960, planned programmed obligations for long range ballistic missiles drop about $230 million (reason is that funding of *Thor* and *Jupiter* is almost completed) from the FY 1959 high of $2.966 billion.

NASA's space probe hardware . . . will be *Vega* and *Centaur,* capable of orbiting 7,500 pounds 300 miles, or of accelerating 1,000 pounds to escape velocity. *Vega* will be an *Atlas* with GE's first stage *Vanguard* (X-405) on top. The advanced *Vega* will add JPL's 6K, a 6,000 pound storable solid engine, as its third stage. *Centaur* will be an *Atlas* with a high energy liquid oxygen and hydrogen engine (Pratt & Whitney) as its second stage.

Navy was highly pleased . . . with the successful launch of *Vanguard II.* Frosting on the cake for Chief of Naval Operations Arleigh Burke was a bottle of excellent scotch whisky he won betting *Vanguard II* would go. The loser: President Eisenhower.

A three-months leave . . . for reasons of health, which begins in March for Navy Under-secretary William B. Franke, has cast doubt on his ever assuming the Secretary's job when Thomas L. Gates leaves. Franke is scheduled to take the job in June.

First shipboard firing of *Talos* . . . was successfully carried out last week by the guided missile cruiser Galveston, off Puerto Rico. Galveston is the first ship to be equipped with the Bendix-RCA surface-to-air missile.

First telescope in space . . . is being readied, according to reports from scientists at the Smithsonian Astrophysical Observatory and Harvard College Observatory. The unmanned vehicle would carry 150 pounds of equipment to scan the sky in the ultraviolet part of the electromagnetic spectrum.

***Bomarc* and *Lacrosse* . . .** will be Canada's major defenses against air attack. Prime Minister Diefenbaker told the House of Commons the decision to scrap the Avro Arrow CF-105 interceptor and switch to missiles was made because potential aggressors now are going from manned bombers to guided missiles. Diefenbaker said the agreement with U.S. is that Canada will pay for one-third of cost of Canadian *Bomarc* bases and the U.S. two-thirds, adding Canada expects "a reasonable and fair share" of contracts for production of technical equipment.

Filling jobs in the Pentagon . . . is becoming an increasingly difficult task. However, two Department of Defense spots were taken last week by Dr. Hector B. Skifter and Dr. Howard A. Wilcox. Dr. Skifter is taking leave of absence as president of the Airborne Instruments Laboratory of Cutler-Hammer, Inc., to be Assistant Director of Defense Research and Engineering (Air Defense). Dr. Wilcox is leaving the post of Assistant Director of Research at the Navy's NOTS, China Lake, facility, to become Deputy Director of Defense Research and Engineering.

Initial *Mercury* tests . . . will be conducted with *Little Joe,* a cluster of four *Sergeant* engines (guidance by Sperry Gyroscope, propulsion by Thiokol) to be designated as TX-3320 and TX-3322. ABMA has a NASA $2.2 million contract to produce the cluster. North American has a $400,000 contract for the casing, transport vehicles and launcher. Thiokol has a $110,000 contract to build small solid rockets (SM-19E1) to be attached to the side of *Little Joe* for initial acceleration.

***Titan* continues high . . .** batting average. Wednesday's short-range (200-300 mile) test firing of first stage from Cape Canaveral was second successful in three attempts. Previous successful test firing was Feb. 6.

Prime contractors looking for major subcontract capability in missiles, rocket engines, ordnance, or electronics will find it at Rheem. With more than 600,000 square feet at Downey, California, the Rheem Defense and Technical Products Division offers a unique combination of experience and facilities that is unmatched in the West.

If you require unusual skills in critical welding or machining operations, be sure to consult Rheem. Rheem will assume the complete responsibility for system, subsystem, or component production, from engineering through manufacturing . . . whatever best suits your requirements. You will be impressed by the "package contract" capability that is available to you.

For the full details on Rheem availability for subcontract assignment, write to Dept. MR-712-1.

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industry countdown

Another entry . . .

in the ALBM is Douglas, with Donald W. Douglas, Jr., being quoted on the West Coast as saying his company has submitted a proposal for an ALBM and a relatively "inexpensive" solid surface-to-surface missile. Latter would be successor to the *Honest John.*

Hispano-Suiza will build . . .

an initial 200 bi-liquid SEPR rockets, Type 841, used as booster engine on the Mirage III interceptor. With a minimum thrust of 1653 lbs., at 52,000 ft. (using two combustion chambers) it has a maximum thrust of 35,450 lbs. Propellants are nitric acid and TX-2.

Terrier or *Tartar* . . .

will be on 51 ships under present Navy shipbuilding programs, including three carriers, three cruisers, and 20 guided missile frigates.

400-mile range . . .

for testing *X-15* in California and Nevada, was developed and built by the Electronic Engineering Co. of California for NASA. Work began in 1956 under $2 million contract. Master control station in the radar instrumentation system is at Edwards AFB.

Big orders for *Scout* . . .

contractors is indicated by a recent AF-NASA agreement. NASA will supply *Scout* specs to AF, who will then have contractors modify the 35,000-pound, four-stage 70 ft. experimental research rocket to suit AF test requirements. AF version is System 609A (m/r, Feb. 23, p. 13). First stage will be an Aerojet Senior, a modification of early *Polaris* motor; second stage will be an improved *Sergeant* by Thiokol; third will be a new scale-up of *Vanguard* third stage by ABL; fourth stage, same as *Vanguard* third, will be by JPL. Minneapolis-Honeywell will have guidance and spin stabilization.

Project *Mercury's* bill . . .

will exceed $200 million. *Mercury* is budgeted for over $58 million in FY 1959, and for $70 million in FY 1960. NASA and McDonnell have signed a definitive contract estimated at $18 million for delivery of 12 capsules during next 14 months. NASA Administrator Glennan told Congress that more than $2 billion will be spent before the nation procures basic rocket engines needed for its space program, and the agency will need 2,500 more employees if the present NASA-ABMA agreement does not work out.

AF screened 350 sources . . .

for its 480L strategic communications support system which may have more fund implications than the DEW line. ITT-RCA were selected from four proposals submitted by teams representing 18 companies. AF required all bidders not to design and engineer the system so as to have advantage in subsequent procurement over other suppliers, and, when feasible, not to compete with other suppliers for future systems and sub-systems requirements.

"Weather eyes" for . . .

Vanguard II were development of Electro-Optical Division of Perkin-Elmer. Mercury battery packs were developed and manufactured by Mallory Battery Co. of Cleveland, a division of P. R. Mallory & Co. Inc. Dow Chemical Co. reports skin and internal structure of satellite are of magnesium.

First large-scale commercial . . .

plant for production of boric oxide will be American Potash & Chemical Corp's Trona, Calif. facility, now under construction.

Movable nozzle of new type . . .

will provide better steering and control of the Lockheed *Polaris.* Conceived by scientists at the Applied Physics Laboratory, Johns Hopkins University, it has been tested successfully at the Navy Propellant Plant at Indian Head, Md. The molybdenum nozzle was designed by the Systems Engineering Division of Cleveland Pneumatic Industries, Washington, D.C., and manufactured by Cleveland's Pneumatic Tube Division in Cleveland.

Vandenberg work schedule . . .

has been stepped up to seven days a week for an 84-hour work week where second *Atlas* complex is shaping up. Three pads of first complex are about completed with one missile on launcher. Second complex, originally scheduled for completion in mid May, now is slated for early April.

...NEWS IS HAPPENING AT NORTHROP

Latest Astronertial Navigation and Guidance system is revealed by Dr. William L. Parker, Chief of Systems Development at Nortronics, a division of Northrop Corporation.

NORTRONICS ASTRONERTIAL SYSTEM—ONLY GUIDANCE CONCEPT READY TO MEET THE CHALLENGE OF INTERPLANETARY NAVIGATION!

READY NOW for the day man first explores the planets, Nortronics' concept of Astronertial Guidance is the most accurate known for long-duration flights. Astronertial Systems now in production deliver a wide margin of added accuracy–using Nortronics' exclusive 24-hour star tracker to correct continuously for the small, then ever-compounding errors inherent in "pure" inertial systems.

OPERATIONAL TODAY in the USAF-Northrop Snark SM-62 – free world's first and only operational intercontinental guided missile – Nortronics Astronertial systems have furnished accurate guidance for more miles than all similar systems combined.

CURRENT NORTRONICS SYSTEMS trim weight to one-tenth, size to one-twentieth that of original systems. They are designed to deliver pinpoint accuracy in applications to all types of space vehicles, cruise and ballistic missiles, terrestrial manned aircraft, surface ships and submarines.

NORTRONICS EXPERIENCE in Astronertial Guidance dates back to 1946 – to the design and development of the first successful intercontinental system. Now, Nortronics offers unique and proven capability in design, development and production of complete and integrated guidance systems, including their ground support and test equipment.

NORTRONICS

Hawthorne, California

A Division of Northrop Corporation

MARCH 2, 1959—VOL. 5, NO. 9

missiles and rockets

MAGAZINE OF WORLD ASTRONAUTICS

NASA Plans Include East-West Minitrack Fence

Other goals are two additional parabolic dishes for continuous deep-space tracking, and developing safe tracking and communications for man in space.

by Paul Means

WASHINGTON—An east-west fence of four Minitrack stations stretching from Western Europe across the Atlantic and the North American Continent to Alaska is an immediate goal of the National Aeronautics and Space Administration.

Of great interest to the electronics industry, completion of the new fence—added to a north-south string of stations already in service—will enable NASA to track satellites of all inclinations, including polar orbits.

The existing Minitrack network can only track satellites with orbital inclinations less than 35 degrees from the equator, and do some non-continuous deep-space tracking. It uses a north-south chain of 11 Minitrack stations in the United States and abroad, ranging in latitude from Maryland to Santiago, Chile.

Two other NASA projects to be completed in the next two years are:

1. Construction of two 85-ft.-diameter parabolic dishes similar to the one at Goldstone, N.M., at Woomera, Australia, and at an undisclosed site in South Africa, for continuous tracking of vehicles traveling in deep space.
2. Development of a tracking and communications system that will insure the safety of Project *Mercury's* first man in space.

• **Funds Picture**—NASA's proposed operational tracking fund of $11.5 million is only a small portion of the overall budget request of $485,300,000 for the agency for Fiscal 1960. But it is more than double the tracking appropriation of $4.3 million approved in Fiscal 1959.

At the same time, however, the Fiscal 1960 request for tracking funds for the Advanced Projects Research Agency is $17 million, a sharp drop from the $23 million fund of Fiscal 1959. ARPA's total budget request is $455 million.

Though no figures for the construction of tracking installations are available, NASA has just asked Congress for an additional $12,050,000 to carry out the projects listed above.

According to NASA Administrator T. Keith Glennan, $3,300,000 of the additional money will be used to construct the east-west Minitrack fence and to improve existing stations; $3,500,000 will be used for initial expenditures on the construction of the large radar dishes in Australia and South Africa; and $5,250,000 will be used to build a Project *Mercury* tracking, communication and radar acquisition network in Southern Texas.

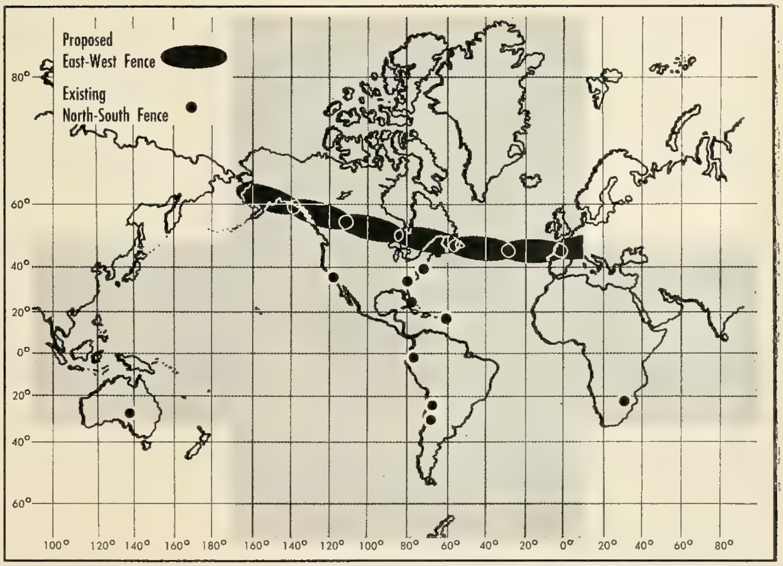
NASA officials say that the large radar dishes and the Project *Mercury* installations will need more money later.

• **Existing stations**—The cornerstone of NASA's current and future tracking operations are the Minitrack stations originally developed for the IGY.

Stations presently in operation are at Blossom Point, Md.; Ft. Stewart, Ga. (this will be moved shortly); Havana, Cuba; Quito, Ecuador; Lima, Peru; Antofagasta and Santiago, Chile; Antigua, British West Indies; Esslen Park, Union of South Africa; Woomera, Australia, and San Diego, Calif.

The four South American stations and the ones at Havana and Ft. Stewart were operated by the Army Signal Corps during the IGY. The Signal Corps staffs are being replaced by contract staffs under technical direction of NASA.

Antigua, a part of the Atlantic



NASA PROPOSES to build new Minitrack stations in Europe, Canada and Alaska. These, plus existing north-south chain, would make possible tracking of all satellites from 0 to 90° inclination. Minitrack costs would total $3.3 million.

Missile Range, is the initial station after orbit for Cape Canaveral launchings, and supplies information during the sub-launching phase along with another station at Grand Turk in the Bahamas.

The San Diego station was operated by the Naval Electronics Laboratory and is now operated under contract by NASA.

The Australian and South African stations are operated by the respective countries as their contribution to the IGY.

These stations comprise a completely functional network with communications headquarters under the direction of the Naval Research Laboratories in Washington, D.C.

• **How it works**—The primary components of these Minitrack stations are:

1. Nine to 15 antennae whose design and installation allow the system to detect signals generated from sources in a fan-like space directly over the station.
2. A highly-developed radio receiver sensitive to signals of 108 megacycles plus or minus five cycles.
3. A precision time section whose counter instrument can tell local time down to the 1/1000th of a second.
4. A phase comparison section which determines the angular position of the satellite. This is accomplished by measuring, electronically, the difference in time required for satellite transmissions to each of two ground antennae spaced 500 feet apart. This is known as the "interferometer" principle.
5. A bank of two recorders which present on a paper chart the signals received from the satellite plotted against an accurate and precise time base. The speed of the chart can be varied from zero to 100 millimeters per second.

Three fixes on a launched satellite by one or more Minitrack stations must occur before the elements of the orbit can be computed. Computation of the inclination and equatorial intersection will give the plane in which the satellite is orbiting. Other elements of the orbit computed by Minitracks are the perigee, period, argument of perigee, and epoch.

With the construction of the east-west Minitrack fence, NASA will be able to track any satellite regardless of orbit, and evaluate the necessary information quickly.

• **Photo fixes**—A second set of satellite and deep-space tracking equipment are the Baker-Nunn photographic satellite-tracking telescopes, developed for the IGY by the Smithsonian Institute and now operated by the Smithsonian under NASA direction.

These instruments fix the position of a space vehicle by taking a picture of it against a star background, thereby determining the vehicle's position with respect to time at different parts of the earth.

THREE STATIONS using huge parabolic dishes will provide overlapping deep-space coverage for unbroken tracking.

The Baker-Nunn equipment is effective only when the space vehicle is in the light and the telescope is in the dark under clear weather conditions. Best periods for optical observation are an hour after sunset and about an hour before sunrise.

These camera-telescopes are currently in operation at Palm Beach, Fla.; Arequipa, Peru; Villa Delores, Argentina; Nani Tal, India; Cadiz, Spain; Olifanstfontein, So. Africa; Mitaka, Japan; Haleaka, Hawaii; and White Sands, N.M.

Additional Baker-Nunn installations will be constructed along the proposed east-west Minitrack fence.

• **Big dishes**—Also aiding NASA's tracking operations are the larger tracking facilities which can send and receive signals over a wider band, allow for reduced power supplies in space vehicles, and work at longer distances.

These include the Air Force's 60-ft.-diameter parabolic dishes, which are in operation in Hawaii and on the Atlantic Missile Rrange, and the numerous helicol antenna tracking units situated throughout the world.

NASA's large 85-ft.-diameter parabolic dish at Goldstone, N.M., built by the Army for its first satellite attempts, will be one-third of a proposed deep-space tracking network designed to continuously track space vehicles to the moon and beyond.

The three stations, at one-third intervals around the earth (New Mexico, Australia and South Africa), will overlap in their deep-space coverage areas so as to provide a continuous tracking pattern, and will be the key tracking apparatus as rockets travel farther from earth.

• *Mercury* **challenge**—A more immediate problem is to provide adequate tracking facilities for Project *Mercury*, insuring the necessary safety for the first man in space. Tracking and communication facilities will have to be more extensive and refined than those currently used for unmanned satellites.

It makes relatively little difference whether the present tracking facilities achieve their fixes on an unmanned satellite on the vehicle's first, second, or later orbits. But *Mercury's* manned capsule is scheduled to make two or three orbits only.

It will therefore be necessary to compute the elements of the capsule's orbit quickly in order to determine the exact time to trigger the retro-rockets for its descent.

To locate the capsule quickly after it has landed, it will be necessary to track it immediately on descent, which is more difficult since it no longer will be in free orbit and will be affected by drag. Without this tracking capability, it will be impossible to recover the man from the capsule in the alloted safety time.

Another problem Project *Mercury* poses is development of an extensive communications network, so that information can be quickly funneled from all over the world to a central computing center.

Initial construction on the Project *Mercury* network will take place in the near future at a location in Southern Texas—the $5,250,000 project announced by Administrator Glennan and referred to earlier.

NASA, DOD Have Widely Divergent Patent Rights

WASHINGTON—The National Aeronautics and Space Administration has the same basic procurement authority as the Pentagon and will follow the Armed Services Procurement Regulation in making contracts, according to John A. Johnson, general counsel of NASA and long-time Air Force general counsel.

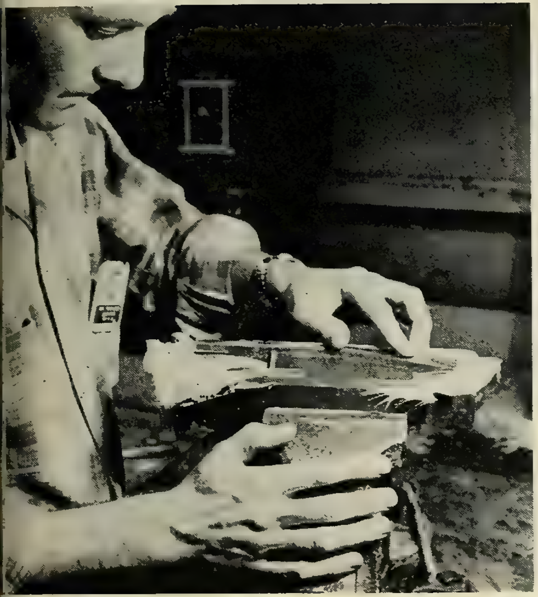
But the same thing doesn't hold for one important field—patents.

NASA is required to acquire title to certain inventions made under its contracts unless the Administrator—on grounds of the public interest—signs a waiver. DOD generally acquires only a royalty-free license.

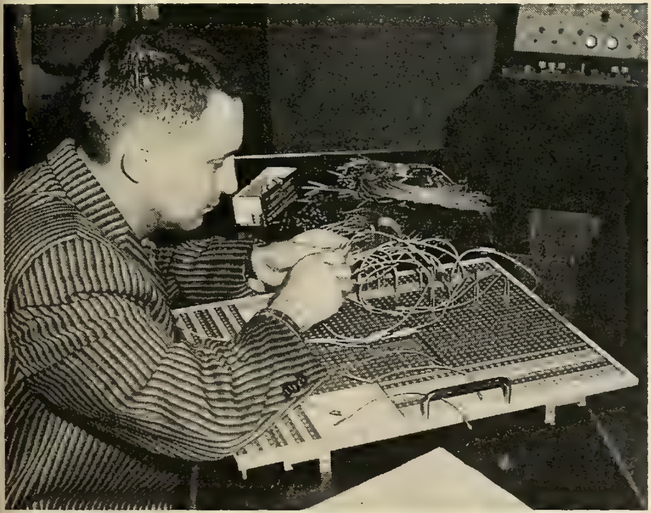
There is no present intention to seek an amendment to the National Aeronautics and Space Act to alter this divergence, although Johnson says it is "undesirable." But he is promising to make every effort to administer the patent section "fairly and objectively."

ASTRONAUTICS in the news . . .

A SUPPLIER to many coal mining operations—Mine Safety Appliances Co. of Pittsburgh—is contributing to the space business. This aluminized asbestos suit is used at NASA's Langley Research Center for protection against wind tunnel heat.



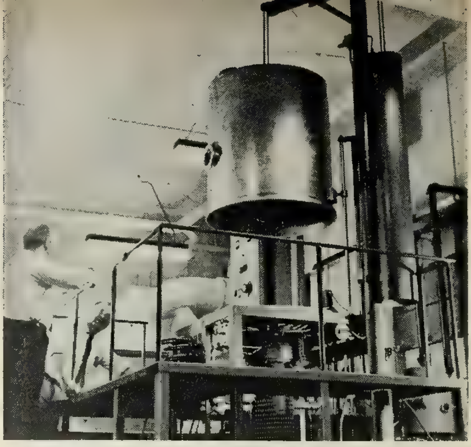
ALLIED CHEMICAL's urethane foam is getting new use as material for wind tunnel test models, particularly at Chance Vought. Open mold is lined with glass cloth and epoxy resin laminated before foam is poured. The smooth skin offers less drag, and is cheaper than wooden surface models.



MARTIN-DENVER has developed a Master Operations Control (MOC) which monitors countdown for the *Titan*, checking out subsystems and testing instrumentation. Here, technician patches in a countdown on the master sequencer program board. Some 200 functions can be checked by the system.

NEW VACUUM TEST chamber which simulates altitudes up to 140 miles has been placed in operation in the environmental physics department of Aeronutronic Systems, Inc. The chamber has an 8-foot diameter. Lights are part of high-speed photography assembly for use in upper atmosphere weather rocket experiments. The company, a subsidiary of Ford Motor Co., has its research center at Newport Beach, Calif.

Singer's Cast Epoxy Resin Mirrors Require No Costly Hand Work



ALUMINUM reflective coating is bonded to plastic replicas in vacuum chambers.

Polishing and finishing eliminated in plastic replica process. Mirrors withstand 20,000g in shock tests

APERTURE of f:0.6 is illustrated by sun rays made visible by smoke.

NEW YORK—A new cast epoxy mirror now in production represents a victory over two of the major drawbacks which have plagued makers of reflective optical components—high cost and long production time—according to Frederick W. Howells, manager of The Singer Manufacturing Company's Military Products Division.

The company's Bridgeport Division has tooled up with high-vacuum chambers and other equipment specifically designed for mass production of the new product known as the Repli-Kote Mirror.

The new mirrors, according to SMPD spokesmen, are guaranteed to cost from one-half to one-fifth as much as ground glass mirrors, and they can be produced at a rate many times faster. With the present tooling, the Bridgeport plant can turn out from 50 to 200 units per day, depending on size. The largest mirror produced to date measures 10 inches in diameter.

The Repli-Kote Mirrors are cast in epoxy resin specially treated to provide durability, and vacuum coated with aluminum for reflectivity. The aluminum surface is overcoated with a protective film of silicon-monoxide. Average thickness of the aluminum coating ranges between five to eight millionths of an inch: and the bonding to the epoxy backing is very rugged.

• **No hand work**—In contrast to glass mirrors, the production of epoxy mirrors does not involve any hand finishing or polishing. The only handmade part in the process is a precision ground glass prototype—or master—from which the casting mold—or negative—is cast. The negative, like the finished product, is made of epoxy resin. The epoxy-backed mirrors can be cast to duplicate faithfully and to minute tolerances any shape that can be produced in glass by precision grinding—including parabolic, hyperbolic, elliptic, and other aspheric shapes normally not reproducible in glass on a mass production basis.

Despite the simplicity of production, the manufacturer says, the physical properties of the epoxy-backed mirrors are far superior to those of glass. Sample replica mirrors have withstood impacts up to 22,000 g in shock resistance tests. Yet precision has been attained in mass manufacture of 6-inch paraboloids with a 5¼-inch focal length concentrating 90% of incident collimated light within 0.1 millimeter diameter.

Resistance to thermal shock is another feature of the new mirrors. The rate of thermal diffusion through epoxy is much greater than it is through glass, and Repli-Kote Mirrors have been transferred directly from dry ice to boiling water without ill effects.

• **Easy mounting**—The new process also simplies the mounting problem since threaded inserts, mounting lugs, or other mounting fixtures can easily be cast into the mirror backing to meet specifications. Mechanical and electronic components can also be molded in the backing.

The plastic replica process was developed by SMPD's research and development arm—Haller, Raymond, and Brown, Inc., of State College, Pa. Immediate application is seen in infrared systems, such as the homing system in the Navy's *Sidewinder* AAM.

Haller, Raymond, and Brown recently also perfected an improved process for coating infrared reflectors to withstand stresses induced by rotation as fast as 5000 rpm. This process permits faster production than does hard anodizing and reduces cost about 80%, according to company spokesmen.

Weather Satellite Will Have Three Cameras

Later meteorological experiments will be responsibility of Weather Bureau Section

by Frank G. McGuire

WASHINGTON—The United States is planning to put a satellite containing three television cameras into orbit soon in the first of a series of such meteorological experiments. Under the cognizance of ARPA, this satellite apparently will be that agency's first project in the field of weather reconnaissance. The orbit sought will be a near-circular one at about 300 miles altitude, giving the satellite a 90-minute period.

Planning of experiments, data reduction and analysis, and application of information from later weather satellites will be the responsibility of the Meteorological Satellite Section (MSS) of the Weather Bureau. MSS will also conduct basic research in connection with the newly-acquired data. Funding will be done through NASA.

The initial satellite will be equipped with three vidicon TV units built by RCA. One will have a field of view about 1000 miles square and resolution of about 2½ miles. The other two cameras will have smaller fields of view, but better resolution.

A cutoff device will prevent the cameras from operating when a large percentage of useful view is out of the cameras' sight due to the satellite's attitude or insufficient illumination. There will be no control system aboard the satellite to affect its attitude once in orbit. It will operate at a low rate of spin—on the order of 10 rpm. Internal power will be furnished by solar battery.

- **Rapid scanning**—The vidicon unit with the wider field of view will be aimed perpendicular to the satellite's spin axis, and the other two will be aimed in the same direction along the spin axis. The cameras will scan for a fraction of a second, then store the data on tape in a two-second operation. The wide-angle-view vidicon unit will operate with an interval of approximately two minutes between exposures and an overlap of about 600 miles in successive exposures.

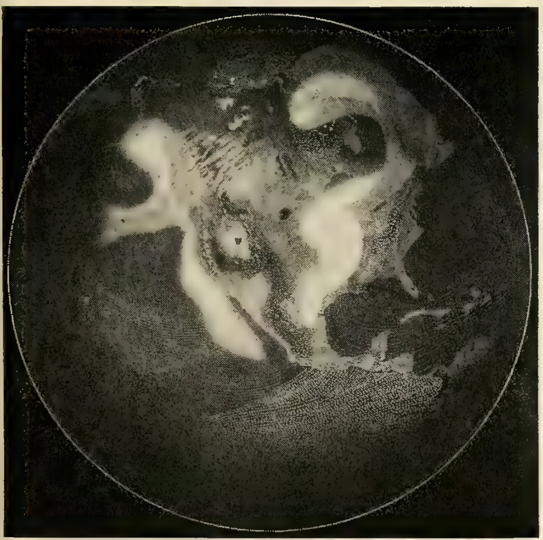
(The first weather satellite will not be established in a polar orbit, but it is anticipated that later satellites will be launched that way, so as to cover the entire earth. In this case, launching will most likely be carried out at Vandenberg AFB, Calif.)

A system of ground control will be utilized to command the satellite's photographic and readout operations. Readout will be triggered to ground stations once on each pass around earth and recorded on film and tape. The data will be forwarded to MSS at the Weather Bureau facility in Suitland, Md.

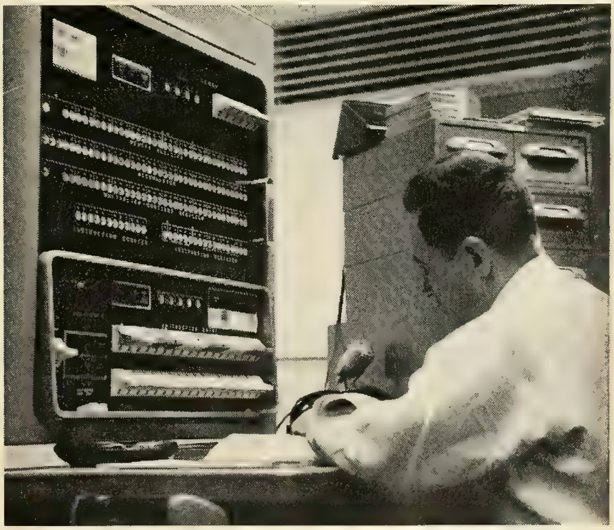
After data reduction is completed, the information gained will be used to supplement observations from ground stations, which the Weather Bureau has no plans of supplanting with satellite equipment.

- **Radiation data**—Five types of radiation sensors will also be included in the satellite's payload. Under construction by the Army Signal Corps Research and Development Laboratory, they will measure various components of radiation emitted and reflected by earth. By thus measuring the earth's albedo, MSS will be able to determine the net intake and outgo of radiation. Distribution of the net heating of the atmosphere, as governed by this radiation parameter, is believed to ultimately control circulation of the atmosphere. An accurate series of data on this phenomenon would be of great value to meteorologists.

All data from the weather satellite



IMAGINARY weather picture taken from a rocket 4000 miles above the earth.



DATA from satellites would be processed at Bureau's Suitland, Md. Meteorological Satellite Section (MSS) facility.

will be available to other nations of the world. For example, dissemination of information might be handled by the World Meteorological Organization, of which the USSR is a member.

- **MSS plans**—The Weather Bureau's Meteorological Satellite Section, with Dr. Sigmund Fritz as section chief, was organized in March, 1958. Later, it was expanded upon the invitation of NASA to act as its agent in the field of weather satellites.

The section has a staff of 14 at present. Tentative plans call for expanding this to 40 by June.

MSS is currently studying photographs from such projects as *HUGO* in order to gain as much experience as possible in interpreting extreme-altitude photographs. Techniques developed during these preliminary investigations will then be available for application to actual satellite data.

Future plans and objectives of MSS are numerous. One calls for a radar installation aboard a satellite to measure cloud structure and precipitation. Vidicon cameras can see only the tops of cloud formations.

MSS would also like to be able to measure surface barometric pressure from a satellite, which it cannot do now. In addition, it wants a stabilized satellite and/or a "stationary" satellite in a 22,000-mile orbit. A trio of satellites which were both stabilized and "stationary" could keep the entire globe under constant surveillance.

Future weather satellites may also measure the effects of ultraviolet and other rays on the lower atmosphere. Also, the radiation emitted by atmospheric gases should indicate the worldwide distribution of water vapor, ozone and carbon dioxide, and could conceivably show temperature distribution near the tropopause and lower stratosphere.

Armour Enters Empirical Rocket Applications

CHICAGO—Armour Research Foundation and its Chemistry and Chemical Engineering Department are establishing a static test site some 50 miles west of here which reflects the recent de-emphasis of combustion in general in favor of the more specific needs of rocket propulsion.

Armour, which has been deeply involved in theoretical combustion studies and laboratory preparation of liquid ozone, is moving more and more into empirical rocket applications. The new test site is equipped with a concrete test stand, instrumentation block house, utilities building and an adequate supply of water and 220-volt electric power.

The test stand was designed for either solid or liquid propellant motors and has a capacity of 10,000 pounds thrust. Currently, it is being used in a materials testing program with a 500-lb. acid-aniline rocket. A test of gaseous fluorine and ammonia combustion was performed on Dec. 27, 1957, in a miniature rocket motor.

The site is being considered for decontamination tests of fluorine rocket motors, possible exotic solid propellants, with provisions to be made if and when liquid ozone is considered safe enough for test in a rocket motor.

- **Large staff**—Armour Research Foundation is a 20-year-old organization with a staff of about 1200 (800 are engineers and scientists). Its personnel are employed in nine research departments. The propellant work is split into two areas—C. Charles Miesse supervises the Combustion Research Section; Gerald M. Platz is Supervisor of Propellant Chemistry Research.

The Combustion Research Laboratory is equipped with numerous test cells for detailed investigation of a wide range of combustion phenomena:

1. Small-scale (2.05-in. ID) jet engine for helicopter rotor tip propulsion.
2. 1.5 x 3.5-in. low-pressure combustion tunnel for high-altitude (4-in. Hg) studies at flow velocities of M = 0.3.
3. 2.0-in. ID low-pressure combustion tunnel for evaluation of combustion characteristics of exotic fuels (under construction).
4. Vertical combustor with settling chamber for investigation of combustion characteristics of low-volatility fuels.
5. Nash vacuum pump with 650 cfm capacity under all pressures from 2-in. Hg to atmospheric.

Propulsion projects have included:

1. Boron chemistry—A five-year program was conducted for the Callery Chemical Company under a contract from the Navy's Bureau of Aeronautics. In general, it dealt with the chemistry of compounds containing boron, hydrogen, and carbon. More specifically, it was concerned with process studies for high-energy fuel Plant No. 2 at Muskogee, Oklahoma.

2. Combustion in low volatile fuels—In an effort to improve combustor performance and increase heat release rates, the Navy has sponsored a basic research program on the combustion of heavy residual fuels. During the three years of this project, analytical and laboratory investigations have been pursued regarding the basic properties of injection, atomization, vaporization, ignition, mixing and combustion. Atomization of liquid fuels has been studied in great detail.

The second phase of this program, initiated recently, involves determination of the mechanism for combustion chamber deposits and corrosion, and establishment of design criteria for eliminating this universal problem.

3. Rocket exhaust gas impingement—For testing the sensitivity of heat-resistant material to high-temperature, high-velocity gases, a specimen was mounted in the exhaust jet of a 220-lb.-thrust liquid propellant rocket. A series of six tests at an average of 60 seconds duration was completed satisfactorily. Although ARF did not name the material, it can be assumed that it was Armour's ceramic-coated metal.

4. Nozzle material evaluation—Also under investigation is a comprehensive study of the mechanism of failure of rocket nozzle materials, as the result of exposure to high-energy solid propellants. Subject evaluation is conducted by the Ceramics and Minerals Division, under the Supervision of S. W. Bradstreet.

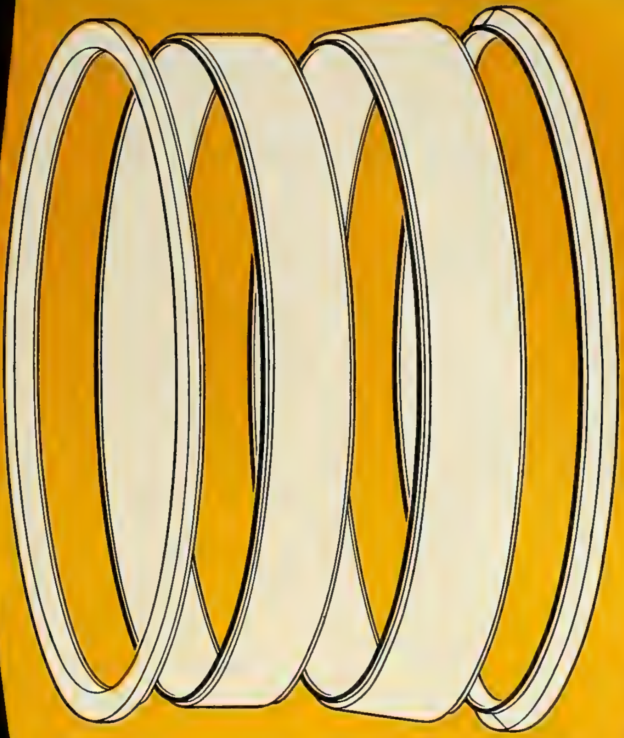
5. Ozone chemistry—Practically at a standstill.

Proposed areas of effort, m/r learned, include:

1. A rocket-turbine power system which might be competitive with the gas turbine if materials can be found to take the higher temperature.
2. Utilization of gases in extraterrestrial atmospheres for combustion. Atmospheres of Venus or Mars could furnish carbon dioxide as a propellant. Most promising reactant with CO_2 would be either boron or beryllium. The reaction of beryllium with CO_2 appears to offer a considerable advantage in heat evolved per unit weight of fuel over any current system in which both fuel and oxidant are carried.
3. Decontamination of HF vapors and aerosols resulting from scrubber effluent or fluorine spills.

Named Managing Editor

WASHINGTON—Donald E. Perry, news editor of Missiles and Rockets Magazine, has been named Managing Editor. Perry, former Martin writer on the *Bullpup, Missile Master*, and *Lacrosse* programs, joined the staff one year ago as an assistant editor.



The two outside flash butt-welded rings were joined to the inner flash butt-welded bands around the circumference by submerged arc welding. The two halves were then welded together to complete the assembly.

Tricky

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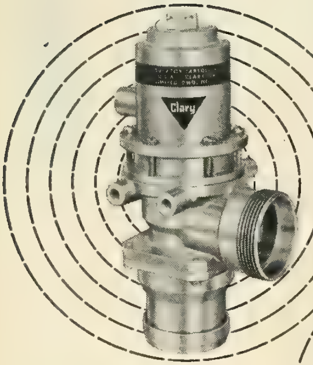
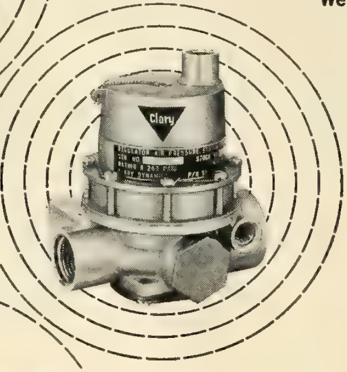


ABSOLUTE PRESSURE REGULATOR maintains an outlet pressure of 18½ to 20 PSIA with variations in flow rate from 3 to 350 SCFM under 30 to 100 PSIA inlet pressure and −65°F. to +350°F.

Weight: 2.1 pounds **Length:** 8.55 inches
Tube Size: Inlet: 1.50 inches
Outlet: 2.00 inches



DIFFERENTIAL PRESSURE REGULATOR maintains an outlet pressure of 6 PSIG ±.25 with flow variations from 3 to 160 SCFM under 10 to 250 PSIG inlet pressure and −65°F. to +350°F.

Weight: 1.5 pounds **Length:** 4.00 inches
Tube Size: Inlet: .75 inches
Outlet: special flange

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Integrated Electronics for Small Missiles

Prime consideration in design and manufacture is that the missile be considered as a round of ammunition

The facets of manufacturing integrated electronics for small missiles are many. This paper presents some of the important factors that must be considered and stresses that design, manufacturing and quality control are inseparable if efficient, reliable small missile electronics are to result. Electronics must be designed and manufactured as an integral part of the missile. The black-box, shock-mount, mounting bracket, appendage-like treatment of electronics has no place in a modern high-performance small missile.

Mechanical design suitable to meet the various environments is a major factor influencing the manufacturing process.

Some of the techniques employed in design and manufacture are mentioned. Any one of these is worthy of a separate treatise. It is not in any way intended to present a detailed discussion but merely to alert the reader to some of the many factors influencing the manufacture of integrated small missile electronics.

The material presented is based on experience obtained in design and manufacture of missiles at the Naval Industrial Reserve Ordnance Plant, at Pomona. Convair-Pomona operates the plant under Naval Ordnance Contracts.

Much of the material contained was originally prepared by K. C. York and Henry Chrystie, Design Specialists at Convair-Pomona. Acknowledgement is due the personnel of the Naval Inspector of Ordnance Office and the Convair Engineering Staff because the information contained herein is their work.

by Gordon E. Sylvester

Assistant Chief Engineer-Product Engineering

Convair/Pomona, Convair Division of General Dynamics Corporation

POMONA, CALIF.—In discussing manufacture of integrated small missile electronics, it is first necessary to understand the philosophy used in the design of the hardware. A small missile should be considered as ammunition, or an educated shell, rather than an airplane with the pilot removed.

This distinction is important because it has considerable effect on our approach to design and manufacturing. In this discussion it is important to understand that the problems of design, quality control and manufacturing are so inter-related that one cannot be discussed without including the other two.

Let us first discuss some important design considerations which, when combined, establish the requirements for the electronics we build for small missiles. These are listed in Fig. 1.

- **Small space and low weight**—Ever-increasing performance is demanded of our modern military vehicles. An important factor governing performance is size and weight.

Therefore, it has become necessary to devise means whereby electronics will occupy less of the total airframe, and also at the same time be able to perform additional and more sophisticated functions than were previously necessary.

Fig. 2 shows a trend in the unit volume occupied by electronics in several missiles. It is interesting to note trends taking place in smaller missile electronic packaging. It is obvious that a reduction in missile length will result in increased maneuverability.

- **Environments known**—Many of the environments encountered in small missiles are well known to the missile and electronics industry. Some of the typical environments which have considerable influence on the product we manufacture are listed in Fig. 3.
- **Testable and visually inspectable**—The total electronics must be built up from functionally testable subassemblies and assemblies in order that an orderly manufacturing and testing process can be evolved. Excessive testing is wasteful; however, too little testing can result in exorbitant rework costs especially when tear-down of complicated assemblies is involved.

Even with various sophisticated testing devices now available including automatic programing, automatic readout, and automatic acceptance or rejection decision, there is still no substitute for good visual inspection during the manufacturing process. Therefore, visual inspection operations must be provided during manufacturing, and designs must be made in such a manner as to readily permit thorough visual examination.

- **Reliability defined**—Much has been written and said about reliability in the past few years. Most of this has

FIG. 1:
DESIGN CONSIDERATIONS
Small Missile Integrated Electronics

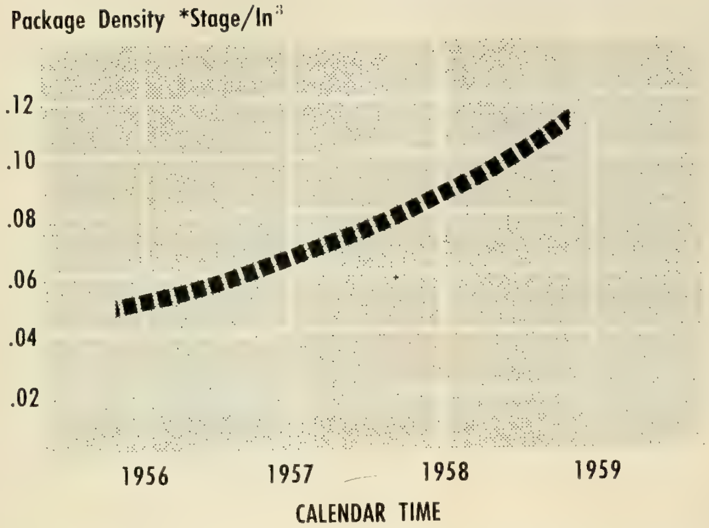
1. Small Space and Low Weight
2. Environments
    - Shock
    - Virbration
    - Temperature
    - Moisture
3. Testable Assemblies and Subassemblies
4. Visually Inspectable
5. Reliable
6. Interchangeability and Spare Parts
7. Minimum Cost in Production
8. Ability to Incorporate Changes with Minimum Disruption of Manufacturing

been directed towards electronics and has centered on design considerations; however, that is not the total story.

In the manufacturing phase, reliability means minute attention to details at each and every step. Each wire, when skinned, must be done in such a manner as not to nick a strand; each soldered joint must be made as nearly perfect as possible; and each process such as cleaning, plating, etc., must be accomplished under controlled conditions such that satisfactory performance of the end product is assured.

I might dwell for a moment on the subject of component parts. Each component part that goes into the missile must be assured of its functional reliability. After a part has been tested and demonstrated to satisfy the design requirements, no changes in process can be allowed until such changes have been demonstrated to yield a product adequate for the purpose intended.

FIG. 2:
TREND IN SMALL MISSILE ELECTRONIC PACKAGE DENSITY



*A "stage" consists of a single electron tube, diode or transistor together with its associated resistors, capacitors, relays, transformers, etc.

FIG. 3: TYPICAL ENVIRONMENTAL REQUIREMENTS

OPERATIVE VIBRATION
A. Electrical Power On—No damage sustained
10g peak
20—1000 cps frequency sweep in each of 3 orthogonal planes
B. Operate within tolerance
5g peak
20—1000 cps frequency sweep in each of 3 orthogonal planes

STORAGE VIBRATION
2g at 23 cps applied in each of 3 orthogonal planes—total 75 hours

STEADY STATE ACCELERATION
40g

SHOCK
Electrical power ON
0—50g in .003 second
50g for minimum .010 second

TEMPERATURE
Operating within tolerance
—40°F to +125°F plus solar radiation and internally induced heat
Storage
No damage sustained
Must function within tolerance after exposure
—65°F to +160°F

MOISTURE
Operate within tolerance
Relative humidity up to 95% may include condensation

It is important that all people engaged in missile electronics understand the extreme importance of controlling changes in manufacturing processes. Many a design has not proven satisfactory in production because some small change was allowed in the manufacturing or quality control process which nullified the functional reliability of the device being built.

- **Interchangeability and spare parts**—We continuously strive for improvement in reliability which should result in fewer failures and less need for spare parts. However, the state of the art has not advanced to the point where spare parts are no longer necessary. In the integrated approach with small spaces available, we can allow only very little clearance between the spare parts—therefore, close control of the mechanical dimensions is necessary to achieve interchangeability.

In addition, and probably even more important in the manufacturing process, is the control of tolerances of the various electrical parameters. Tolerances used in the manufacturing process can be easily established by simply adding arithmetically tolerances of the various parts that make up an over-all system to obtain the system tolerance, and then adding the effects of various environments. However, this method of tolerance derivation can result in tight tolerances prohibiting economic manufacture.

Methods of tolerance derivation and justification are beyond the scope of this paper. However, it should be pointed out that a method of combining tolerances on a probability basis is being employed and should result in considerable reduction in production cost, and yet provide a high degree of assurance that a missile, when fired, will function satisfactorily to accomplish its mission.

Of course, certain rigid quality control procedures must necessarily accompany such a system in manufacturing.

- **Low cost of production**—Ammunition, as we consider small missiles, usually means large quantities in production. Therefore, the cost of producing each item becomes extremely important. Our design, manufacturing and quality control processes must be developed to allow for minimum costs for production and yet yield a weapon entirely suitable for accomplishing its mission. Particular attention must be given to integrating the design and mauufacturing in such a

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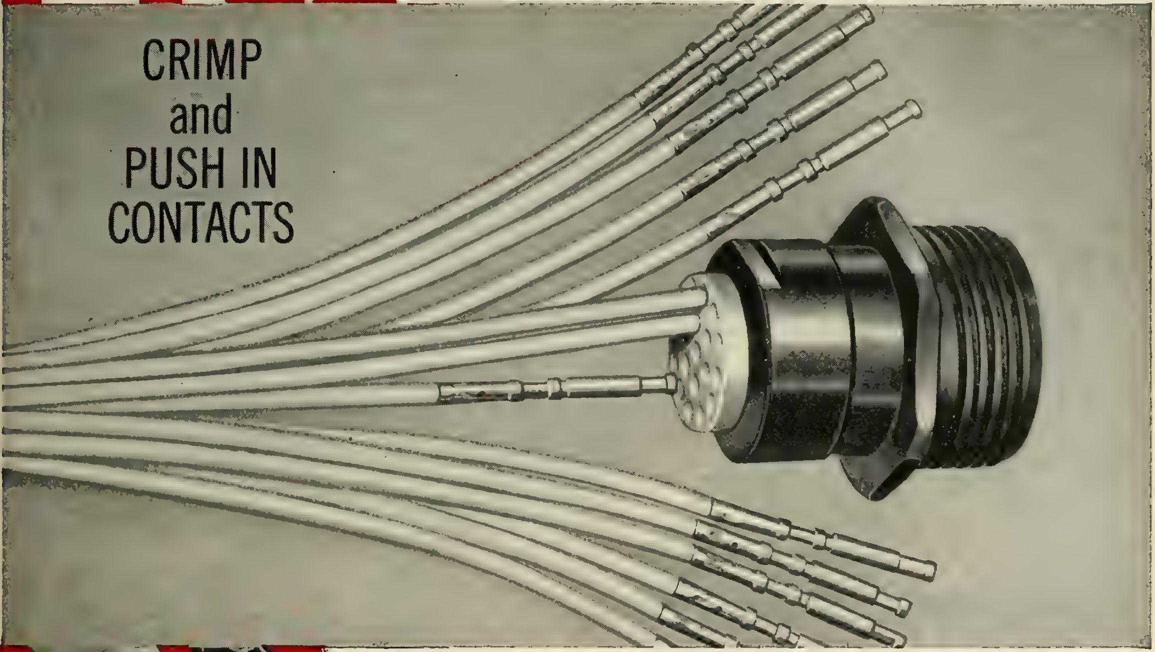

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6. *Two-piece Mod. 2 insert* is interchangeable within Standard Pyle-Star-Line barrel shells with *three-piece Mod. 1 insert.*
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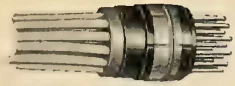

Mod. 2 Insert, 19-Pole with metal housing removed

Environmental Limits of Pyle-Star-Line connectors	
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Corrosion Resistance	Salt Spray: 300 days without failure
Dust Resistance	Exceed requirements of MIL C-5015D
Shock Resistance	50G Minimum
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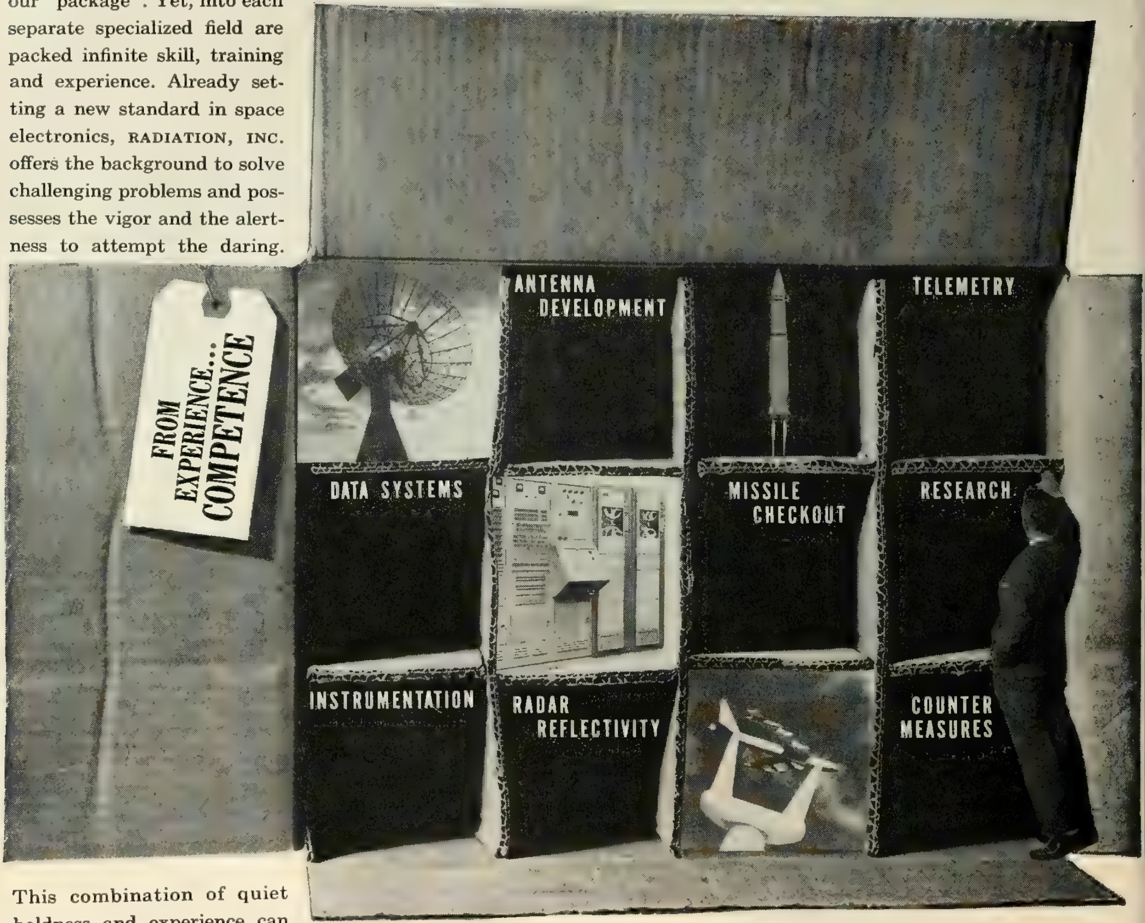

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manner as to permit this happy combination.

- **Ability to readily incorporate changes**—As the missile technology improves, we find that we can improve the performance of our vehicle. This usually leads to changes within the electronics. If, for instance, we make all of the electronics in one assembly without some breakdown, necessary changes become extremely difficult, if not impossible, to incorporate without a major change in the missile.

Therefore, design and manufacturing processes must be devised which will permit ready incorporation of improvements with minimum disruption of manufacturing.

Mechanical Design for Shock and Vibration

Shock and vibration requirements probably influence the manufacture of integrated electronics more than any other one factor, and therefore are worthy of a detailed discussion.

Design and manufacturing of missile electronic equipment would be simplified if shock and vibration isolation could be used. Isolation, though desirable, is not compatible with design requirements for many reasons.

First, as we have pointed out earlier, the space allotted to electronics must be kept to an absolute minimum. Isolation requires that a significant clearance be provided around equipment. It has been estimated that a clearance of .3 inch around each component would be required to provide protection for a system having a 50cps resonance under a 70g acceleration loading. Additional space is required for the isolation mounts.

The problems of dimensional control and mechanical interchangeability commensurate with economical production further complicate the situation by requiring even additional space.

The second objection to isolation is possible adverse effects upon the missile control system. The mass of the missile electronics may be as great as ⅕ the total missile mass. Supporting this mass on a low-frequency isolation system would induce a low-frequency missile vibration mode which could have a deleterious effect upon missile guidance.

These two reasons combined with other minor ones virtually preclude the use of shock and vibration isolation within the missile.

- **Early missile equipment**—Early missile equipment packages were designed using conventional aircraft and electronic practices. Chassis were fabricated from thin sheet metal. Vacuum tubes were supported from sockets and so forth.

This equipment had to be extensively tested to assure that it would function in the missile environment. This environment in some cases exceeded specifications for individual parts to such an extent that special testing of parts such as vacuum tubes resulted in yields as low as 20%, even though the tubes themselves met their individual specification requirements.

Then, after the units were assembled, they were vibration-tested extensively to determine their weaknesses. The weaknesses found were corrected by rework. Finally, after rework, equipment would sometimes function in the environment, but it had very poor reliability.

- **Effects of excessive acceleration**—Probably the main source of improper operation in the early equipment was excessive acceleration caused by resonant amplification of low-frequency vibration. Some packages amplified 5g input vibration to as high as 100g's at certain frequencies below 300cps. A component part failure would occur when the part was perfectly satisfactory for even 10 to 15g acceleration.

This failure would occur if a part and its mounting structure had close to the same resonant frequency. In this case, the part's resonant mode would be excited to a destructive amplitude.

- **Current missile equipment**—Missile equipment is now designed and manufactured to vibrate as an integral unit with no excessive resonant amplification throughout the vibration spectrum. Since shock and vibration isolation is not compatible with the missile, design and manufacturing processes were developed to eliminate excessive resonant amplification of vibration.

Elimination of vibration amplification produced excellent results. Missile equipment now has more damage resistance under shock and vibration than the original equipment would have on standard aircraft isolation mounts. Current equipment is designed and manufactured to have great internal rigidity. Packages are only microscopically deformed by the missile shock and vibration environment. This produces excellent damage resistance.

In addition to the considerations for mechanical design for shock and vibration, the small missile must be capable of fast warm-up, i.e., ready to fire very quickly after initial application of electrical power. This capability must not be impaired throughout the operating temperature regime. At the same time, this device may be held in readiness for instantaneous firing, and therefore, must be capable of operating continuously over long periods of time without suffering damage.

In addition to ambient temperature considerations, such other factors as skin temperature due to high speeds, internal heats generated by the auxiliary power supply or other devices, and particularly, heat generated by the rocket motor and its exhaust must be given detailed consideration as to their effects on the integrated electronics.

Producibility and/or Cost Reduction

Producibility is the ability to produce equipment in quantities and at a minimum cost. How can this be achieved? One way is to consider the principle source of production costs—namely manhours.

We can strive for cost reduction by reducing the manhours required to produce a finished article in all stages of assembly starting at the raw materials (which, incidentally, are a very small part of the final cost). We can further reduce the using costs by reducing the manhours required to ship, operate, maintain, and handle, etc., the equipment and by obtaining the maximum usable life from it.

The time to reduce manufacturing costs is in the early stages of design. If the basic costs are not held to a minimum at this time, then it will be too late and all that can be done will be to beat on the heads of the efficiency experts in the production department. Any failure on their part to produce efficiently must be charged back to the initial design.

- **Standard hardware designs**—A principal aim on hardware is to have an adequate selection of items of known performance available to assemble into a useful arrangement with prior knowledge that these parts will perform as expected.

This can be interpreted to mean that there should be certain standardized items such as chassis, terminal boards, blocks, panels, etc., which will have been previously designed and tested in various combinations under the required environmental conditions so that we will not be faced with hardware design and testing each time we need a new electronic device.

Furthermore, these items should be interchangeable according to a defined pattern so that expansion or change in the electronic system can be accommodated in the factory with minimum cost and effort.

- **General considerations**—The decision

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on the manufacturing method to be used to obtain a piece of hardware should not be made solely by the designer. Instead, he should know what manufacturing methods are available and design so that at least one of these methods may be used.

The design should, wherever possible, allow for a choice of manufacturing methods, bearing in mind that a decision may be made to obtain manufacture of the item in various facilities.

Wherever possible, future designs intended for quantity production should be capable of being made on automatic manufacturing (automation) machinery in existence or being developed. An automation machine should not be developed to fit a design; it must be the other way around.

- **Sizes and shapes**—Packaging schemes for integrating electronic apparatus into missiles which are cylindrical-shaped resolve into two basic classes:

  Class I. Rectangular (orthogonal) blocks, bits, and pieces (which generally are easier to manufacture).

  Class II. Odd shapes (such as sectors) (which generally are more efficient of space utilization.)

Therefore, the selection of the actual configuration of modules should be treated as an entirely separate problem from any decision on a general arrangement of the equipment. The lower manufacturing costs resulting from Class I must be weighed against improved space utilization, which may result from Class II, and the price in manhours or dollars which may be paid for an improvement in space utilization at the expense of producibility must be carefully considered.

Odd shapes such as sectors, pie shapes, wedges, discs, doughnuts, etc., can be designed so as to use almost all of the available space, but their use should be limited to special applications because of the following advantages of the rectangular configurations:

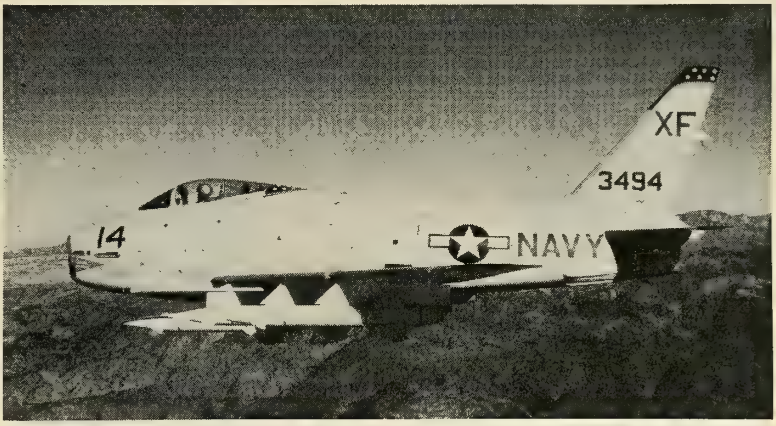
1. Rectangles may be used as part of other systems, larger or smaller in size, or entirely different in nature, shape, or application.
2. Rectangles are easier to make.
3. Because of their greater ease of manufacture, rectangular parts may be produced on a shorter time scale.
4. It is easier to handle and store rectangular pieces. Careful consideration and application of rectangular modules during design can often offset any space advantage attendant with odd-shaped assemblies.

- **Repairs vital**—Most designs must be capable of repair at any time in their life. The more convenient this is, the better. The possible field repair of an item should not be prevented by the design or manufacturing method used. The repair of an item should not be purposely prevented by design when, in an emergency, there may be no other way to obtain satisfactory operation.

- **Materials, processes and techniques**—

In general, the following should be considered:

1. The first choice should be those for which the factory is already trained and equipped.



MARTIN's *Bullpup* tactical air-to-surface missile is one example of the "educated shell" which utilizes integrated electronics.

2. Second choice would be those the factory can accommodate with only a little effort and little or no new equipment.

3. We should consider very carefully just what we are doing to a factory by requiring that they learn and equip for an entirely new material, process or technique.

4. Old, well-known, and very common materials or processes may (because of the ease of obtaining and handling them and training employees to use them) be a better choice than the newest, untried and inexperienced idea which may result in only a slight gain. This depends, of course, on just what the design requires.

5. Inevitably it will be necessary to develop and utilize new materials and processes. Trouble has occurred when development of these was not started in time to meet production requirements. There must be complete understanding and cooperation between design, manufacturing and quality control groups in order that all requirements can efficiently be realized.

6. All new materials, processes, and techniques must be approved for production use by engineering and must be acceptable to the factory before being specified on drawings. There must be mutual agreement or blood, sweat, and tears. The designer cannot adopt the attitude of "I will design it and they can make it. That's what they are paid for." This will only result in chaos.

- **Manufacturing modification**—Almost all electronic component parts must be modified in some manner prior to actual assembly on a terminal board, chassis, etc. This modification must be kept to an absolute minimum to reduce costs.

For example, a resistor cylindrical in shape with axial leads at each end is practically never used as purchased. The leads must be cut, bent, formed, cleaned, or dipped before the part can be used. All of these operations add to the cost of this part because they all require manhours.

A standard method of modifying all similar parts in the same or in several ways will result in appreciably lower costs. For example, all cylindrical parts less than ¾-inch long could have the leads cut and bent so as to be inserted 3/16-inch deep into holes 1 inch apart.

This need not be done by hand since tools can be built or purchased to do it automatically. The parts can be procured from the vendor and mounted in various ways so as to be inserted in the tools for automatic modification of the parts.

- **Tooling savings**—Uniform and standard hardware will reflect in the lower cost of uniform and standard tooling. For example, a standardized cross-hatch or grid pattern has been developed for locating terminal points on a standard etched circuit board. A tool may be made that will be capable of punching or drilling holes at all terminal points at once, but with a selective device built in so that it could be set to punch or drill only a specified group of holes.

This one tool can then be set to punch a very large variety of terminal boards. The net result will be a well-made punch or drill jig to do a family of jobs instead of a family of tools each able to do only one job.

A board of this type can be sent down an automatic assembly line where component parts insertion heads adjusted to the same cross-hatch pattern can be used to insert parts. The ultimate in design would be standard locations for component parts so that the heads will not need to be reset for a different or new assembly.

Some general considerations with regard to tooling (including factory test and inspection equipment):

1. Rectangular hardware allows the use of the standard adjustments on many machines and eliminates the need for many adapters, jigs, fixtures, etc.
2. The ideal situation would be no tools or test equipment. The best compromise is the minimum required to do manufacturing, servicing, testing, maintenance and inspection.

- **Production testing**—Production testing, a crutch to design and manufacturing, is vitally necessary in the manufacturing scheme. The importance of tolerance considerations has been previously pointed out. Production testing can most economically be accomplished when it conforms to an integrated plan devised by cooperative effort between the design, manufacturing and quality control groups.

Such a plan will provide the necessary assurance during the various manufacturing stages without over-testing or excessive use of testing time. It has been found that the test plan is a very necessary adjunct to the manufacturing process.

In small missile manufacturing it has been shown that a carefully thought out, well prepared test plan greatly simplifies the problem of introducing the missile into the manufacturing process, considerably assists in plant layout and determining functional flow of material in the factory, and gives the customer an assurance of what he is accepting when the completed missile is presented for final acceptance.

These production functional tests are now conducted on automatically programed and read-out test equipment. Universal automatic test equipment which permits the application of various AC and DC stimuli with acceptable responses all controlled by punched cards are now in use. A permanent printed record is made on an electric typewriter.

To demonstrate satisfactory equipment performance in a vibration environment, production testing under vibration is sometimes employed. A successful production vibration test has been developed which utilizes a fixed fundamental frequency below 50 cps at 5g combined with 40g vibratory transient tapping. This tapping is obtained by a cantilevered system excited by the fundamental frequency.

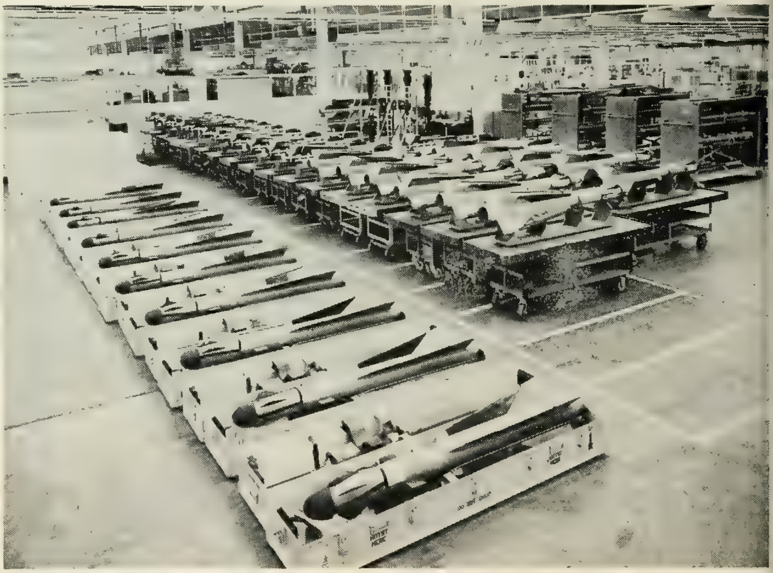
Other Design Considerations

- **Heat transfer**—As a general rule we do not usually have a problem of supplying or retaining heat, but heat removal is one of the biggest problems in electronic packaging.

The heat may be removed by radiation, conduction, or convection or by combinations of these. Any one of the three methods may be improved upon by appropriate design. For example, fins can be added to improve radiation (and convection) or better conductors of heat may be used—such as silver or copper.

In general, mechanical systems for the removal of heat (blowers, refrigerators, etc.) are not compatible with small missile application.

Recent experience indicates that for compact integrated electronic systems such as utilized in small missiles, heat is best removed by conduction provided that there is enough mass in the surrounding structure to serve as an adequate heat sink. Heat conduction paths must be provided carefully from the source of the heat to the area where the intensity of the heat is low enough that it is not harmful.


INTEGRATED ELECTRONICS is a must for such missiles as the *Falcon*, assembly line-produced at Hughes Aircraft, in Tuscon.

Since perhaps the largest heat source is vacuum tubes, they must have firm-fitting wrappers or shields of a form which makes many points of contact with the tube envelope and with the adjacent heat-conducting materials. In the case of sub-miniature tubes, they may be wrapped and inserted in holes in metal blocks which will act as the heat sink or will conduct to a heat sink.

It is indeed fortunate that the requirements for heat transfer coincide with those for shock and vibration requirements.

- **Component parts**—Watch out for the new and glamorous part that is such an advance in the state of the art and does everything better. The most reliable parts are those of conservative designs that have been made by the million for several years, under good conditions of quality control.

Watch out for the company with the big deal, the salesman who is doing you a favor by letting you have enough of his new and wonderful gadget to take care of your prototype. Have you ever heard these words: "We know we have a problem, but don't worry, we will straighten it out by the time you get into production?"

When a decision to use the unique item is made, any one of dozens of things may happen—and usually that which is least expected. For example, the following case histories:

1. The vendor's product really was very good. Unfortunately for us, many others found out about it at the same time we did, so the vendor was swamped with orders—some of them larger than ours. Accordingly we found ourselves way down on the list and we had to beg for our smaller needs.
2. The vendor's product was good, but it was made on a pilot line set-up, on a laboratory basis. We investigated the plant and found that he had under construction adequate facilities to take care of our anticipated needs, so we committed ourselves to his item. The trouble was that it took him quite a while to get his expected quality out of the new machinery and the new people.
3. The vendor was an old, established and well-known firm, with an excellent reputation. He had an item which he, we, and others evaluated and were all happy with, so how could we miss on this one? We ordered and received thousands of the item.

   Suddenly, to our horror, we found that all those items that we had so thoroughly inspected no longer gave the same results. Several months had gone by and many were now installed in the finished product, but there had been a long term drift in one of the characteristics due to an insignificant change in the vendor's process. There was only one thing for us to do—take them out—the hard way.
4. This one was another good product. We tested it, of course. It had some features no other had, and even though there was only one source of supply, we recognized the risk and investigated the vendor very thoroughly, satisfying ourselves that we were safe enough. He wasn't overloaded with other people's orders, he had good backing, his people were happy, etc.

   We covered all the angles. And what happened? It was no fault of his that his neighbor's plant burned down and took his with it. We had no choice but to get him going in a new plant as fast as possible, and we bit our nails down to the first knuckle while we were doing it.

- **Structure and parts supports**—As previously discussed, in the past sheet metal was extensively used in the manufacture of the missile electronic supports. Sheet metal parts are, in general, relatively cheap to manufacture once the forming dies are available. They also provide a lightweight structure.

Recently, however, there has been a trend away from the sheet metal parts toward castings. We have found that the use of thin-wall castings provides a fairly cheap structure. At the same time, it provides the high degree of rigidity necessary to meet the vibration and shock environments.

These structures are less susceptible to warpage, thus permitting close spacing of the mechanical parts and still allowing mechanical interchangeability. Sheet metal parts are susceptible to warpage during assembly and in order to insure mechanical interchangeability even with moderately close spacing, it has been necessary to utilize assembly jigs and fixtures and then provide expensive gauges to insure complete interchangeability.

- **Component part mountings and etched boards**—Electronic component parts are supported from the etched circuit board where that technique is employed, or supported on terminals where point-to-point wiring is employed. In general, epoxy filled glass boards are used. At least one of the missile projects utilizes point-to-point wiring exclusively.

We have found the use of etched circuit boards highly desirable, and by controlling the design and manufacturing processes, we have been quite successful in meeting the environmental requirements.

One interesting sidelight on the use of etched circuits is the problem of coordination required between design and tools. We have found it expedient to lay out all etched circuits on a standard grid pattern. This way, standard spacings on tools can be employed.

Etched circuits are not without their own problems, however, particularly where high-impedance circuits are involved. It is necessary to protect the circuits of the boards from the effects of humidity. They must be kept cleaned in such a manner that foreign materials cannot cause leakage between circuits, and thus, impair the operation of the device.

Again, in order to meet shock and vibration requirements, it is necessary that components such as resistors, capacitors, etc., must be mounted to the boards in such a manner that they form an integrated mass.

This is usually accomplished by potting and encapsulation techniques. However, potting and encapsulating materials have a tendency to change electrical characteristics when exposed to various environments. Ground or guard circuits are sometimes used on etched boards to nullify the effects of leakage.

Soviet Author Writes On Thermal Materials

The Soviet publication, Journal of the Air Fleet, has published an article by S. N. Kan which discusses the various methods of overcoming the problem of heat.

Despite recent enthusiasm for such materials as alloys based on aluminum or titanium and those who favor cooling or insulating during flight, the ideal material would be one with a zero coefficient of linear expansion, according to Kan. In principle, he states, it is possible to produce alloys with a low coefficient of linear expansion. For example, an admixture of 43% nickel to steel reduces the coefficient of linear expansion by a factor of two, and this value is retained up to a temperature of 430°C.

The author notes that chemistry is affording new solutions to the problem and cites the ability of some modern plastics to retain their strength at temperatures of -50° to +170°C and even higher. In addition, these are only half the weight of aluminum and one-eighth the weight of steel.

Some are even stronger than steel, Kan points out, and says it is possible to utilize these materials successfully in the manufacture of rocket and aircraft engines. There also are plastics which are one-tenth the weight of cork and have high heat-insulating and soundproofing properties.

The glass panels and canopies of manned vehicles can be replaced by polycarbonates, usable within wide temperature ranges. He notes a high degree of interest in plastics reinforced with glass fabric or fibers, which are

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SOLID STATE ENGINEERS AND SCIENTISTS to do applied research on precision linear circuitry employing solid state devices using analog to digital conversion techniques and sample data. Experience in feed-back amplifier design desirable. Also opening for engineers with experience in precision, low-level linear circuits employing solid state, to work on analog to digital conversion techniques.

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INDUSTRIAL CONTROL ENGINEERS to perform precision AC and DC electric measurements. Assignments in amplifier design, relay circuit logic, test equipment development, analog to digital conversion, and noise reduction.

CIRCUIT DESIGNERS to design transistor amplifiers, relay lines, transistor tube conversion circuits. Develop systems circuit specifications, perform circuit evaluation experiments and reliability criteria. Other openings in circuit design for magnetic devices.

MATHEMATICIANS to do digital computer programming, handle analysis-of-variance and multiple-regression type problems. Design experiments for wide variation of engineering applications. Knowledge of application of probability or game theory desirable.

two-thirds as heavy as duraluminum, two-ninths as heavy as steel, but just as strong as nonferrous metals and alloys. By means of heat treatment, Kan continues, closely packed sheets of glass fabric, or glass mats, impregnated with resin can easily be fashioned into large scale sections for aircraft and missile construction.

The plastic Fluoroplast—4 is distinguished by its high-temperature stability. Parts made from this material may be used within a temperature range of approximately −200°C to +250°C. Fluoroplast—4 may also be included as an ingredient of heat-resistant varnishes which remain unchanged even at temperatures of 400°C.

OIT Releases Reports on Beryllium and Molybdenum

WASHINGTON—An Air Force report evaluating the five processes for fabricating beryllium is now available from the Office of Technical Services of the U.S. Department of Commerce.

Best results were achieved, according to the report, from the process of cold compacting followed by upsetting.

Also available from the Department is a report containing extracts of a 1956 Navy-sponsored symposium on the technology of molybdenum and its alloy. Included are excerpts of 14 papers on molybdenum as a structural material.

About the Cover

The powerplant for Britain's *Black Knight* re-entry test vehicle, shown on this week's m/r cover, consists of four Armstrong-Siddeley gamma rocket engines rotatable in paired trunnion mountings for control of pitch, yaw and roll.

Propellant for the vehicle is high-test hydrogen peroxide and kerosene, providing a thrust level of 16,400 lbs. at sea level and almost 19,000 lbs. in vacuum.

Design work on the 35-foot-long *Black Knight* began in 1955 and it made a successful first flight on Sept. 7, 1958, traveling 60 miles downrange at Woomera after achieving a 300-mile altitude.

The present contract on *Black Knight* calls for a batch of 24 single-stage vehicles. With the addition of a solid-propellant second stage now being developed by Saunders Roe, altitudes of 600 to 1500 miles are expected.

The British are using the re-entry data gained from experiments with *Black Knight* to further the development program on *Blue Streak*.

U.S. Buying *SS 10-11* for Forces in Europe

by Frank G. McGuire

WASHINGTON—The United States is currently conducting negotiations for the "imminent" purchase of several thousand French *SS 10* anti-tank missiles from Nord-Aviation, m/r has learned. The weapons will be used to equip American forces in Europe. The U.S. government is also purchasing an unspecified number of *SS 11* missiles.

As Pentagon officials phrased it: "We are definitely buying the *SS 10*, regardless of the fact that others are still under evaluation. It's not a question of 'If' . . . it's 'When'? Licensing of U.S. manufacturers is another question, as yet unsettled."

The other missiles still under consideration are the *Kobra*, a German design, and the Vickers *Vigilante*, a British design. Although these are said by their manufacturers to be lighter and simpler than the *SS 10* and *SS 11*, the U.S. is taking a close look at their kill-ability. Nord-Aviation officials, commenting on the *SS 10* kill-ability, said, "A hit is a kill," and evidently have proven their point to the Pentagon's satisfaction.

- **Established ability**—Training of operators on the *SS 10* and *SS 11* has been brought to a point where the average operator makes 80 to 90% hits of all missiles fired. The warhead of either one of these missiles will definitely knock out any tank in existence today, according to Nord-Aviation. Armor penetration of the *SS 10* is 16.54 inches.

The *SS 10* crew is nominally two men, but only if it is desirable for the firing operator to be in a remote position from the launcher (such as atop a hill). In a pinch, one man can operate the system.

Officials have stressed that the *SS 11* is not a replacement for the *SS 10*, but rather a complementary weapon. French officials were reluctant to discuss the *SS 12*, but it is assumed that it is of the same family as its numerical predecessors, only much improved.

The main difference between the *SS 10* and *SS 11* is weight, range and striking power. The *SS 10* is basically an infantry weapon designed for close combat. The *SS 11*, a heavier missile, may be used by infantry (since it uses the same ground equipment as *SS 10*), but is primarily for use aboard vehicles such as jeeps, helicopters and landing craft.

- **In operation**—Operational equipment for the *SS 10* is comprised of a transport box and launcher; control stick similar to that used in aircraft; a signal generator; a selection box, and sighting equipment.

In the field, the transport box becomes the launcher for the missile. The control stick, connected to the signal generator, causes square waveform signals to be produced at a frequency of 12.5 cycles per second. These signals cause the spoilers to vibrate at a fixed frequency, but through variations in the position of the control stick, they hold the spoilers in one position longer than another, thereby causing a change in the pitch or yaw attitude of the missile.

The selection box passes the waveform signals to the particular missile selected for firing by the operator. A firing sequence control system in this unit governs the sequence of launching of the various missiles in the multiple launcher.

The operational field equipment for the *SS 11* consists of a metal transport/launcher box and a standard fire-control post, comprised of the generator, control stick and one or two selection boxes. The ground equipment for the two missiles is mostly interchangeable.

Nord-Aviation also has under production the *Type 5103* air-to-air or air-to-ground missile, the *CT-10* and *CT-20* target missiles and the *SS 12*.

SS *10/11*—COMPARED PERFORMANCES

NORD AVIATION	Range[1]		Minimum radius of turn yds	Approx. speed mph	Maximum duration of flight sec.	Average percentage of impacts on targets	Penetration
	Min. practicable yds	Maximum yds					
SS 10 Type 5203	330	1750	710	180	20	80%	With shaped charge 16.54 in. of steel plate.
SS 11 Type 5210	550	3830	550	425	22	90%	With shaped charge 19.6 in. of steel plate 50.8 t/sq. in. tensile strength.

[1] The range depends on the position of the operator, on the configuration of the ground, on the training of the operator, etc. The figures indicated are minimas.

SS *10/11*—COMPARED STATISTICS

NORD AVIATION	Dimensions			Total weight (lbs)	Propulsion	Guidance	Warhead	
	overall length	body diameter	span				Description	Weight (lbs)
SS-10 Type 5203	33"86	6'50	29"53	33,07	Solid propellant rocket. Two stages. Booster stage imparts missile velocity of 260 ft/sec. Instant speed remains constant during its flight.	Wire control.	Hollow shaped charge or mixed charge with fragmentation charge for anti-personnel use.	9
S-11 Type 5210	3'10	6'46	20"47	63	Solid propellant rocket. Two stages. Booster stage imparts missile velocity of 330 ft/sec. in 1.4 second. Sustainer stage invelocity to 624 ft/sec. in 22 seconds.	Wire control.	Hollow shaped charge for anti-tank warfare (125 AC) or fragmentation head anti-personnel (140 AP)	13

contract awards

The National Aeronautics and Space Administration has made public a breakdown of its Research and Development contract awards from Oct. 1, 1958, through this Jan. 31—the first four months of NASA's existence.

The report lists 49 separate contracts involving $105,395,000 out of the Fiscal 1959 budget. This is $5 million more than the entire amount earmarked for R&D last year by the National Advisory Committee on Aeronautics, forerunner of NASA.

The awards are listed below. The figure in most cases represents both the 1959 obligations and the total amount of the contract. Where the total amount exceeds the 1959 amount, the total is given in parentheses. In several of these cases, the total figure covers a period of several years and represents a working estimate of what the total will be. In three instances an asterisk appears in parentheses, meaning that the total amount of the contract is still under negotiation.

$8,160,000—**Jet Propulsion Laboratory, California Institute of Technology,** for research.

$110,000—**Yale University,** for molecular study.

$1,900,000—**Naval Research Laboratory,** for partial support of Space Sciences. Division sounding rockets program.

$7,120,000—**Air Force Ballistic Missile Div.,** for earth satellites (including *Thor-Able* boosters).

$8,540,000—**Army Ordnance Missile Command,** for *Juno II* boosters.

$80,000—**Bureau of Standards, Department of Commerce,** for computing services.

$130,000—**Alton Engineering Co.,** for alterations to buildings at Bellevue Annex.

$2,000,000—**Naval Research Laboratory,** for partial support of Space Sciences Div.'s earth satellite program.

$270,000—**Bureau of Standards,** for research on rubidium frequency standards.

$10,000 ($19,320)—**Iowa State University,** for reduction analysis.

$2,110,000 ($2,600,000)—**Army Ordnance Missile Command,** for lunar probe projects.

$2,000,000—**Air Force Ballistic Missile Div.,** for lunar probe projects.

$200,000—**Naval Ordnance Test Station,** for lunar probe projects.

$40,000—**Bureau of Standards,** for computing services.

$8,990,000—**Air Force Ballistic Missile Div.,** for space probes.

$340,000—**Army Ballistic Missile Agency,** for deep-space study.

$1,300,000—**Jet Propulsion Laboratory,** for deep-space study.

$10,000—**Bureau of Standards,** for computing services.

$150,000—**Army Corps of Engineers,** for construction of building addition at JPL.

$40,000 ($292,000)—**Iowa State University,** for space probe instrumentation.

$23,500,000—**Naval Research Laboratory,** for support of the Vanguard Division, Space Projects Center.

$2,150,000—**Army Ordnance Missile Command,** for 100-ft. inflatable sphere.

$430,000—**Air Force's Wright Air Development Center** for "state-of-art" work on rocket engines.

$2,000,000 ($3,400,000)—**Jet Propulsion Laboratory,** for development of 6000-lb.-thrust storable propellant system.

$10,000,000 ($102,000,000)—**Rocketdyne Div., North American Aviation, Inc.,** for 1,000,000-lb.-thrust rocket engine.

$1,900,000—**Atomic Energy Commission,** for Rover Program (nuclear rocket engines).

$75,000—**Government of Peru,** for operation of earth satellite radio tracking and receiving stations for six months beginning Jan. 1, 1959.

$80,000—**University of Chile,** for operation of two earth satellite tracking and receiving stations beginning Jan. 1. 1959.

$600,000 (*)—**Bendix Radio Corp.,** for operations of Minitrack stations in South America and Cuba for 18 months beginning Jan. 1, 1959.

$120,000—**Smithsonian Astrophysics Laboratory,** for photo reduction equipment.

$470,000 ($2,500,000)—**Smithsonian Institution,** for tracking and data reduction services.

$60,000—**Endebrook-White Company,** for modification of impact basin to provide working space for Space Projects Center personnel.

$140,000—**Minneapolis-Honeywell Regulator Co.,** for automatic flight control systems for manned space flight.

$110,000—**Douglas Aircraft Co.,** for propellent tank assemblies for high-energy fuel rockets.

$180,000—**Solar Aircraft Co.,** for high-energy fuel rocket thrust chambers and necessary tooling.

$100,000—**Navy Bureau of Ordnance,** for *X-248* rockets.

$1,120,000—**Navy Bureau of Ordnance,** for *X-254* rockets.

$1,020,000—**Navy Bureau of Aeronautics,** for *Jupiter* seniors.

$90,000—**Army Ballistic Missile Agency,** for *XM-45* rockets.

$620,000—**Army Ballistic Missile Agency,** for *TX-33-20* rockets.

$1,400,000 (*)—**Air Force Ballistic Missile Div.,** for *Atlas D* boosters.

$5,600,000—(*)—**Air Force Ballistic Missile Div.,** for *Atlas D* boosters.

$120,000—**Army Ballistic Missile Agency,** for *XM-45* rockets.

$70,000—**Aerolab Development Co.,** for booster hardware, sets for *TX-33*.

$110,000—**Thiokol, Inc.,** for *XM-19E1* rockets.

$2,200,000—**Army Ballistic Missile Agency,** for *TX-33-20* and *TX-33-22* rockets.

$4,490,000 ($15,500,000)—**Army Ordnance Missile Command** for parts of *Redstone* boosters.

$400,000—**Missile Div., North American Aviation, Inc.,** for transport vehicles and launcher (S-91-4).

$2,740,000 ($4,450,000)—**Army Ordnance Missile Command,** for *Jupiter* boosters.

Recent contract awards by the armed services include:

ARMY

$2,619,599—**RCA Defense Electronic Products,** for reduction, evaluation and interpretation of data obtained under measurement program.

$814,395—**Western Electric Co. Inc.,** for *Nike* spare parts and components. (12 contracts.)

$565,000—**Rocketdyne Div., North American Aviation,** for rocket engines and for design and development. (two contracts.)

$364,378—**Dunn Construction Co., Birmingham, Ala.,** for static test tower modification and support facility at Redstone Arsenal.

$1,178,246—**The Martin Co.,** for R&D on the *Pershing* system.

$650,000—**Sancor Div., Siegler Corp.,** El Segundo, Calif., for production of launching system components for *Nike-Hercules* (add-on contract from Consolidated Western Steel Co.).

$2,949,651—**Daniel Construction Co. of Alabama,** for construction of engineering building at Redstone Arsenal.

$112,360—**Douglas Aircraft Co., Inc., Charlotte, N.C., Ordnance Missile Plant,** for *Nike* spare parts and components.

$99,876—**Westinghouse Electric Corp.,** for detailed study of synthetic spectrum radar instrumentation.

$88,832—**Hoover Awning and Mfg. Co.,** Miami, for bag assemblies and radome covers for Redstone Arsenal.

$79,735—**Raytheon Manufacturing Co.,** for *Hawk* repair parts.

AIR FORCE

$2,600,000—**Marquardt Aircraft Co.,** for *Bomarc* ramjet engines.

$2,100,000—**Crosley Div., Avco Manufacturing Corp.,** for *Falcon* components.

$500,000—**The Talco Engineering Co., Mesa, Ariz., a subsidiary of the Gabriel Co., Cleveland,** for development and production of rocket catapults for aircraft emergency escape systems.

$14,460,000—**Massachusetts Institute of Technology,** for air defense R&D (additional payment for facilities at AF Cambridge Research Center).

$3,100,000—**Systems Div., Consolidated Electrodynamics Corp.,** for *Atlas* ground support equipment (subcontracts from Convair Astronautics).

$3,000,000—**Lear, Inc., Grand Rapids, Mich., Div.,** for coordinate converter systems for *Bomarc* program (a follow-on order from Boeing).

$240,598—**Aerojet-General Corp.,** for research on ultra-energy fuels for rocket propulsion, upper-atmosphere power plants, mechanism of combustion of composite solid propellants, and continuation of research on kinetics of solid phase reactions (four contracts).

$142,500—**Polytechnic Institute of Brooklyn,** for continued research on analytical and experimental study of high-frequency oscillatory combustion and of scaling of rocket motors.

$135,000—**Convair Division, General Dynamics Corp.,** for investigation of use of sub-zero coolants in machining.

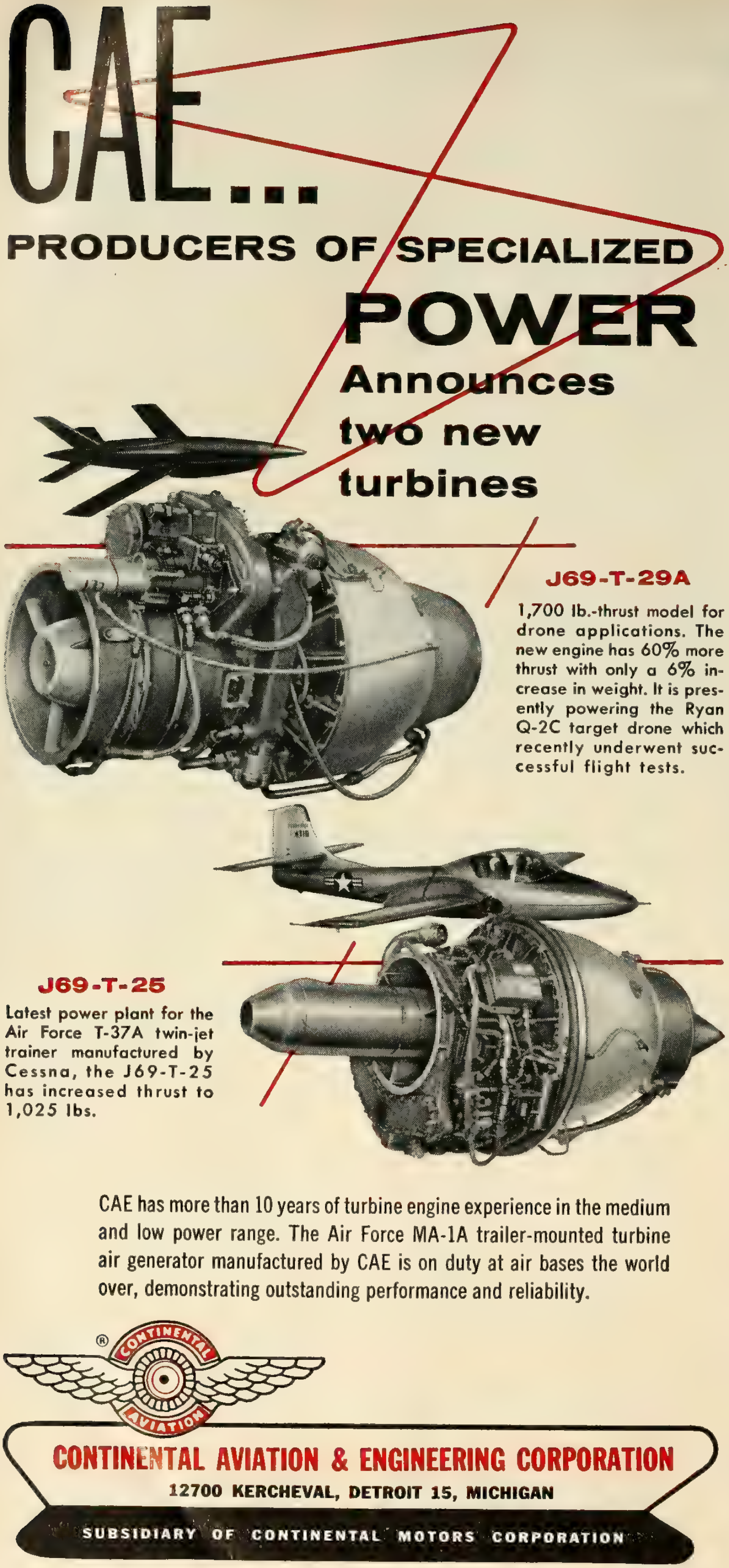
NAVY

$1,909,654—**Aerojet General Corp.,** for rocket motors.

$396,459—**G-M Laboratories, Inc.,** Chicago, for servo motors (two contracts).

$259,046—**Bendix Aviation Corp., Montrose, Pa., Div.,** for synchros.

$60,595—**Arinc Research Corp.,** Washington, D.C. for production reliability improvement of program of guided missile electron tubes.



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J69-T-29A

1,700 lb.-thrust model for drone applications. The new engine has 60% more thrust with only a 6% increase in weight. It is presently powering the Ryan Q-2C target drone which recently underwent successful flight tests.

J69-T-25

Latest power plant for the Air Force T-37A twin-jet trainer manufactured by Cessna, the J69-T-25 has increased thrust to 1,025 lbs.

CAE has more than 10 years of turbine engine experience in the medium and low power range. The Air Force MA-1A trailer-mounted turbine air generator manufactured by CAE is on duty at air bases the world over, demonstrating outstanding performance and reliability.

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missile people

Vice President **William G. Reynolds** and General Counsel **Joseph H. McConnell** have been elected executive vice-presidents of Reynolds Metals Co. The new positions are said to reflect expansion of the company's operations and "the outlook for further expansion of the aluminum industry."

Directors of Thompson Ramo Wooldridge, Inc., have elected four operating executives of the corporation's Thompson Products divisions in Cleveland to vice presidencies. They are **Pierce T. Angell,** engineering manager of TRW's Tapco Group, **Robert E. Cummings,** manager of the Products Valve division, **William M. Jones,** manager of the Commercial Electronics Group, and **Carl L. Kahlert,** manager of the Replacement division.

R. R. Henely has been appointed Neosho Plant engineer for Rocketdyne division, North American Aviation, Inc. **Harold W. Bell,** director of North American's Missile Div.'s Aero-Space Laboratories, will serve as a member of the NASA Research Advisory Committee on Missile and Spacecraft Aerodynamics.

George F. Hannaum, director, Industry Planning Service, Aircraft Industries Association, has been named assistant general manager of the Association. The new assignment will be in addition to his current duties as director of IPS. AIA said the move is designed to maintain more frequent personal liaison among member companies and closer internal coordination of Association activities. AIA's Materials Procurement Committee has named **W. L. Hoffman,** materials manager of Chance Vought Aircraft, Inc., as chairman, and **E. D. Carter,** director of Materiel & Procurement for The Martin Co., as vice chairman, of the Committee for 1959. The two Committee officers succeed **F. L. Dobbins** of Boeing Airplane Co., and **James Mattern** of Sperry Gyroscope Co.

Carlos C. Wood has been named to the new post of director of advanced engineering planning, Douglas Aircraft Company. Formerly chief engineer, Long Beach division, Wood will be succeeded by **Charles S. Glasgow,** assistant chief engineer. Wood will be responsible for planning engineering programs and forecasting technical trends five to 15 years ahead.

George F. Cooper has been named administrative assistant of Hercules Powder Co.'s Baccus, Utah, plant. Since May, 1958, Cooper has been Personnel Department superintendent at Allegany Ballistics Laboratory, near Cumberland, Md.

letters

Jupiter Theodolites

To the Editor:

We were very pleased to see the prominent attention you gave to the azimuth alignment theodolites (m/r Feb. 2), and their important role in helping to assure the accuracy of long-range missiles.

There is one additional point that deserves mention. That is that the particular theodolites we produce for the *Jupiter* were developed jointly with the Army Ballistic Missile Agency at Redstone Arsenal. The group there, under Dr. Walter Haussermann, Fritz Mueller and Henry Rothe were responsible, and deserve credit for the overall alignment system development. Our responsibility was to develop and produce instruments to meet the highly precise requirements of that system.

Carlton W. Miller
Electro-Optical Division
The Perkin-Elmer Corp.
Norwalk, Conn.

Missile Magnesium

To the Editor:

With magnesium alloys being used in more than 20 different missiles, it was a decided surprise to read in Alfred J. Zaehringer's article in the Jan. 26 issue of m/r that "missile applications (for magnesium) exist but are small."

Because of security regulations, it is impossible to present a detailed listing of magnesium missile applications for publication. However, your second annual Engineering Progress Issue, dated July 28, 1958, listed magnesium as a "major material" in the *Falcon I* and *II, Bomarc, Mace, Snark, Nike-Ajax, Nike-Hercules* and *Sparrow III.* In addition to these, magnesium is used in varying amounts in the missile and the guidance equipment structure of the *Regulus II, Vanguard* launching vehicle, *Matador, Nike-Zeus, Talos, Terrier I* and *II, Falcon III, Tartar, Atlas, Polaris, Jupiter* and *Titan.* A substantial interest in magnesium alloys has been shown by designers of more advanced missiles and space vehicles.

The magnesium-rare earth and magnesium-thorium alloys were among the first commercially-available light-metal alloys to provide useful strengths in the elevated-temperature range. HK31A-H24 sheet and plate are being used at temperatures up to 550°F and HM21A-T8 sheet and plate are being used at temperatures exceeding 700° F. Similar magnesium elevated-temperature alloys are available in cast, forged and extruded forms as well. For equal weight, magnesium alloys remain the strongest commercially-available structural materials over a wide temperature range, where strength is based on buckling and rigidity.

The article also states that magnesium has suffered because of "relatively high cost and the contention that production is too small for widespread use in a strategic area." The total cost of using a material depends not only on the cost of the metal itself but also on the cost of fabricating the end article. In many cases simple magnesium monocoque structures have proven to be less expensive than more complex structures of heavier metals in doing the same job. As for production, it should be noted that (1) output of primary magnesium can be multiplied several times through the use of currently unused capacity, (2) the magnesium industry has built far into the future in its sheet, extrusion and casting capacity and is able to activate a very substantial additional capacity for military requirements when called upon, and (3) magnesium is one of the metals (the only other is molybdenum) in which the United States is self-sufficient.

Clayton L. Dickey
Public Relations Department
The Dow Chemical Company
Midland, Mich.

Present Threat

To the Editor:

Congratulations on the much hardened logic of your 16 February editorial in m/r. I appreciated the piece for two reasons. First, because of the realistic approach, and then, dear to my heart, since it implies the significance of the manned threat. Not only today, but for more than a few years to come.

Somewhere in the blaze and glory of our steel fingers of fate that are probing ever upward from Canaveral, many of us have lost touch with Bears and the Bisons—a too real monkey on the back. It's a sort of national rationalization. "Why worry about something that can already kill us—let's worry about something that is going to be able to kill us." The psychological sop is all too obvious—"going to be able" is so much less horrendous than "can."

Captain Ernest A. Beasley, Jr.
Ch., Press and Magazines
Office of Information Services
Ent Air Force Base
Colorado Springs, Colo.

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missile business

by Reed Bundy

The National Aeronautics and Space Administration expects to invest more than half-a-billion dollars in Fiscal 1959-60 in contracts with industry in support of its ambitious space programs. This is small potatoes compared to military contracting, of course, but it's a huge jump over NASA's predecessor, the National Advisory Committee for Aeronautics. Last year NACA's R&D program totalled only about $100 million—and this was entirely in-house.

NASA's contract funds from all sources will be approximately $220 million in 1959 and $330 million in 1960. The great bulk of the 1959 money is already programed (see p. 33 of this week's m/r).

How the half-billion will be spent was outlined recently by Albert F. Siepert, NASA's Director of Business Administration, in a speech before the Nassau-Suffolk Industrial Procurement Conference on Long Island. Siepert said about 50% will be devoted to procurement of vehicles and instruments, or scientific investigations in space which cover sounding rockets, earth satellites, lunar probes and deep-space probes. Some 20% will go for propulsion technology, including development of solid fuel rockets, high-energy fuel rockets, the 1.5-million-lb.-thrust single chamber nuclear rocket engine development, and auxiliary power units to be used in payloads.

Another 20%, according to Siepert, will be slated for developing technology for manned space flight, including construction of the first manned capsule under Project *Mercury*. About 6% will be spent for specific investigations of satellite applications in meteorology and communications. And the balance will go into tracking and data acquisition and advanced space technology.

Industry need not fear, the NASA official said, that it will have to learn a "new system" in order to do business with the civilian space agency. Although NASA has independent status and will operate under its own procurement regulations, Siepert said, its contracting and procurement policies will "conform as nearly as practicable" with the Armed Services Procurement Act and its subsequent regulations.

"A major milestone" on the way to the Air Force's goal of fixed-price type contracts was reached with negotiation of a $25-million contract with Rocketdyne Division of North American Aviation. The contract, calling for IOC production of *Thor* engines, was hailed by Maj. Gen. Ben. I. Funk, commander of the Ballistic Missiles Center, as the "first time in the history of the (AF) ballistic missiles program" that a fixed-price-incentive type contract had been worked out.

The Pentagon has reported to Congress that it is working on standardization plans for guided missiles. There are now seven Federal Supply Catalog classes covering basic end items and equipment of missile systems.

The 80% reimbursement provision for cost-type contracts has been written into the Armed Services Procurement Regulations. It authorizes reimbursement of prime contractors for 100% of the payments made to subcontractors so long as such payments do not exceed 80% reimbursement basis for cost-type subcontracts.

Some ups and downs: Douglas Aircraft Company has reported that its missile business in 1958 increased 109% over 1957. Its annual report to stockholders cited a new record output of $415.6 million in missiles, components and ground-support equipment during the year. But net earnings fell off—in line with company predictions to stockholders—from $30,665,000 in 1957 to $16,847,000 in 1958. . . . Conversely, Bendix Aviation reported a rise in earnings in the first quarter of its fiscal year—and a drop in sales. The company said earnings for the quarter which ended Dec. 31 rose to $5,157,864 from $4,897,486 a year earlier. Sales and other income, however, fell from $167,064,856 a year earlier to $154,494,028 . . . . General Dynamics Corp. estimated net sales for 1958 will exceed $1,500,000,000, approximating the record sales of 1957. But earnings are expected to be under the 1957 record.

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when and where

MARCH

IRE, AIEE and Association for Computing Machinery, 1959 Western Joint Computer Conference, Fairmont Hotel, San Francisco, March 3-5.

Institute of the Aeronautical Sciences, Flight Propulsion Meeting, (classified), Hotel Carter, Cleveland, March 5-6.

Second Western Space Conference and Exhibits, Great Western Exhibit Center, Los Angeles, March 5-7.

Gas Turbine Division of the American Society of Mechanical Engineers, Turbine in Action, Cincinnati, March 8-11.

Third Annual Shock Tube Symposium, Old Point Comfort, Ft. Monroe, Va. For details: Armed Forces Special Weapons Center, Kirtland AFB, Albuquerque, N.M. Attn.: SWRS R. R. Birnkoff. March 10-11.

Support Equipment Institute, Organizational Meeting, Statler Hotel, Washington, D.C., March 12.

American Society for Metals, 11th Western Exposition and Congress, Pan-Pacific Auditorium and Ambassador Hotel, Los Angeles, March 16-20.

The American Rocket Society, 1959 Sectional Meeting, Daytona Plaza Hotel, Daytona Beach, Fla., March 23-25.

Institute of Radio Engineers, National Convention, Coliseum and Waldorf-Astoria Hotel, New York, March 23-26.

Society of the Plastics Industry, 16th Annual Conference, Pacific Coast Section, Hotel del Coronado, San Diego, March 25-27.

American Society of Mechanical Engineers, Instruments and Regulators Division Conference, Cleveland, March 29-Apr. 2.

Society of Automotive Engineers, National Aeronautic Meeting, Hotel Commodore, New York, March 31-Apr. 3.

APRIL

Conference on Electrically Exploded Wires, sponsored by the Thermal Radiation Laboratory of the Geophysics Research Directorate of the Air Force Cambridge Research Center, Somerset Hotel, Boston, Apr. 2-3.

1959 Nuclear Congress, Municipal Auditorium, Cleveland. For information: Engineers Joint Council, 29 West 39th St., New York. Apr. 5-10.

American Welding Society, 1959 Welding Show and 40th Annual Convention, International Amphitheatre and Hotel Sherman, Chicago, Apr. 7-10.

Air Force Association, World Congress of Flight, Las Vegas, Nev., Apr. 12-19.

Aeronautical Training Society, 17th Annual Meeting, Las Vegas, Apr. 16-17.

American Society of Tool Engineers, Annual Meeting, Schroeder Hotel, Milwaukee, Apr. 18-22.

American Rocket Society, Man-in-Space Conference, Hotel Chamberlain, Hampton, Va., Apr. 20-22.

Institute of Radio Engineers, Spring Technical Conference on Electronic Data Processing, Cincinnati Section, Engineering Society Bldg., Cincinnati, Apr. 21-22.

Institute of Environmental Engineers, 1959 Annual Meeting, La Salle Hotel, Chicago, Apr. 22-24.

American Rocket Society, Controllable Satellite Conference, Massachusetts Institute of Technology, Cambridge, Apr. 30-May 1.

MAY

Institute of Radio Engineers, 11th National Aeronautical Electronics Conference, Dayton, Ohio, May 4-6.

Instrument Society of America, 5th National Instrumentation Flight Test Symposium, Seattle, May 4-7.

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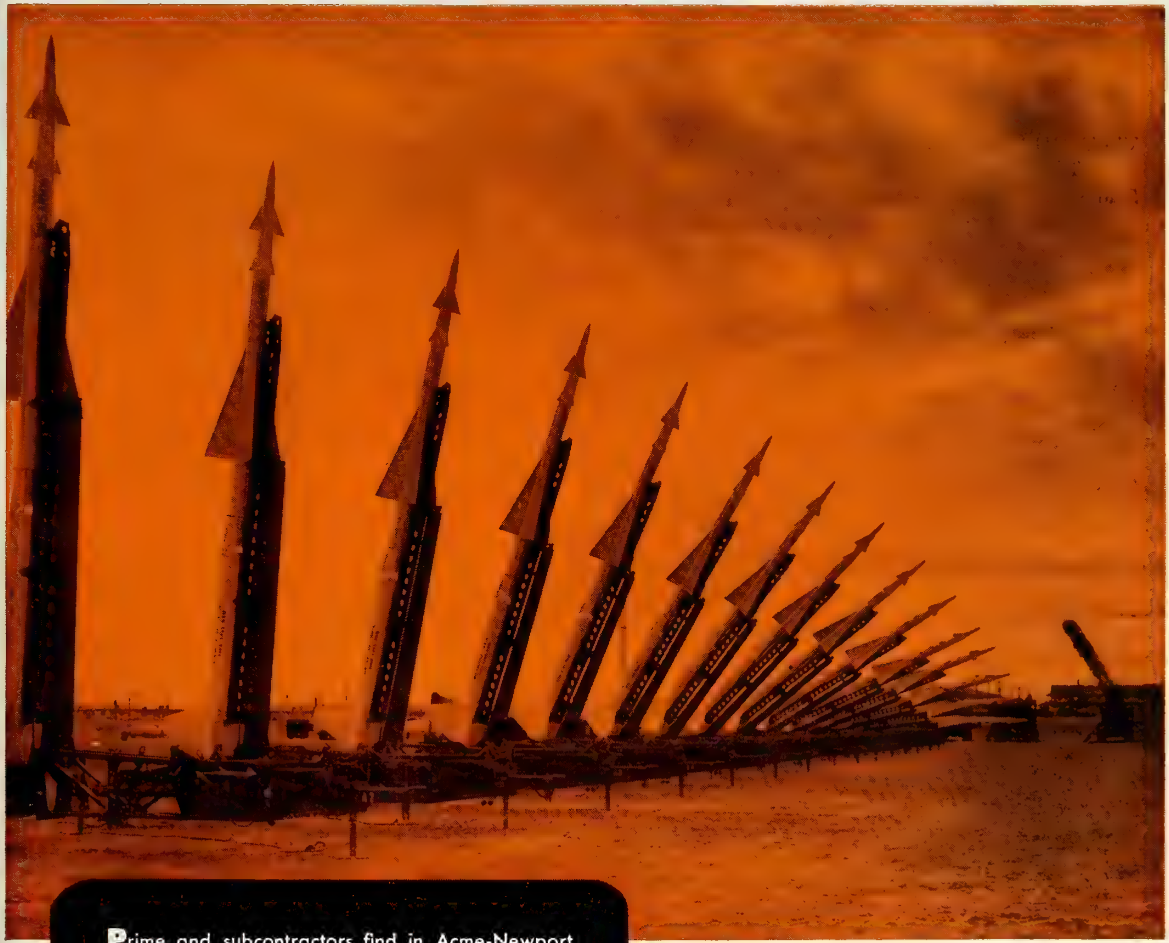

U. S. Army Photograph

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missiles and rockets

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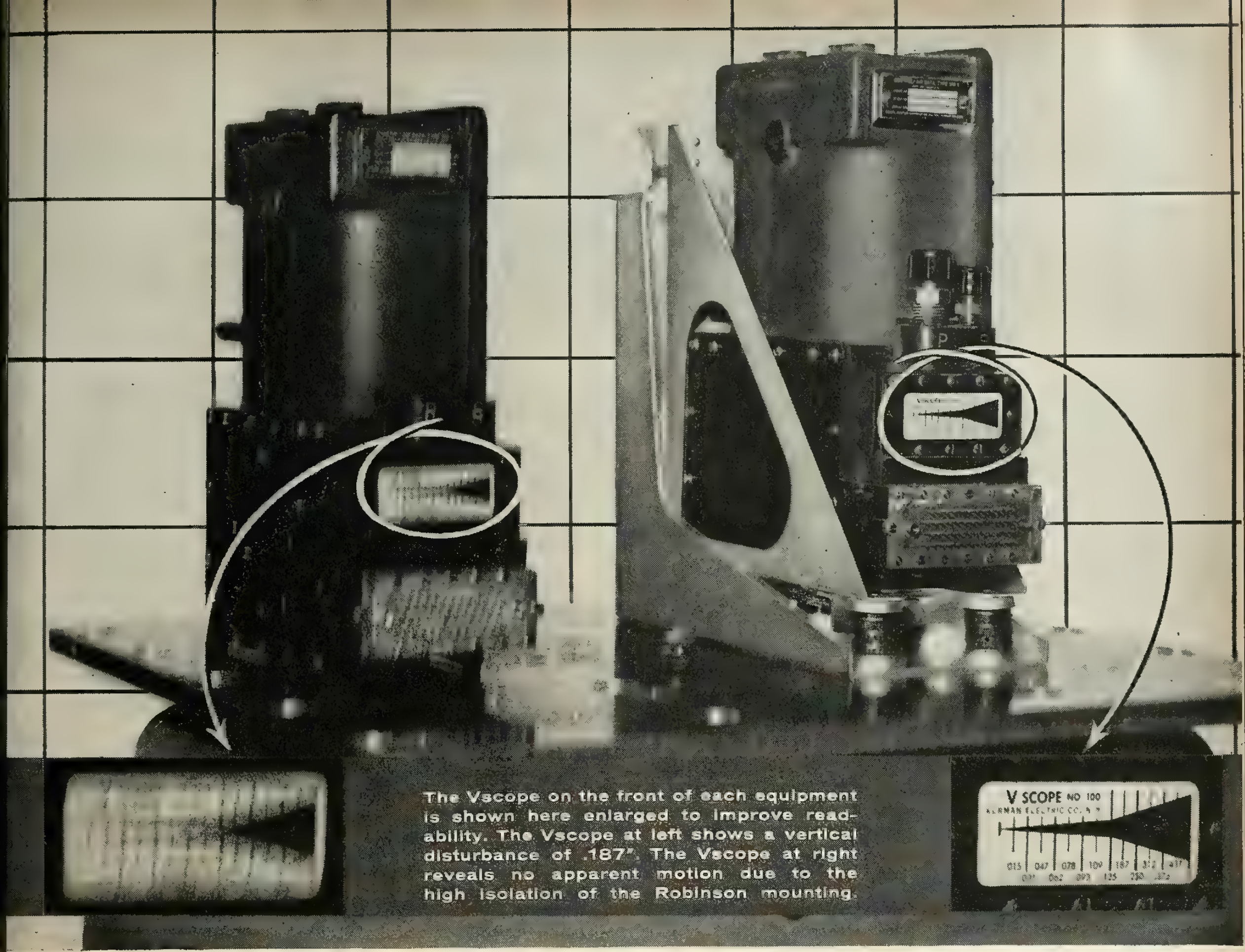

The Vscope on the front of each equipment is shown here enlarged to improve readability. The Vscope at left shows a vertical disturbance of .187". The Vscope at right reveals no apparent motion due to the high isolation of the Robinson mounting.

12.0 "G" reduced to 0.6 "G"

This Is Environmental Protection!

Look at the above illustration, showing two Bendix air data sensors on an electromagnetic shake table. Notice the left hand unit which is mounted solidly to the oscillating head of the shaker. The image is blurred because a vibratory input of about .187" double amplitude at 35 c.p.s., equalling an acceleration force of 12 "g's", is being applied directly to it.

Now look at the right hand unit mounted on a Robinson engineered mounting system . . . some difference! The clear image of this equipment shows the typically high isolation efficiency (over 95%) of the Robinson MET-L-FLEX® mounting design.

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missiles and rockets

MAGAZINE OF WORLD ASTRONAUTICS

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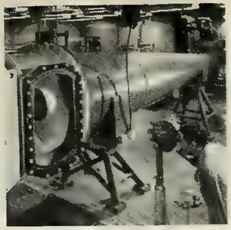
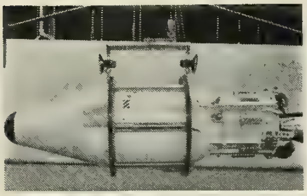
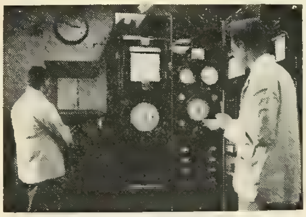


COVER: AF's Arnold Research Center shifts to space-missile projects (p. 31).

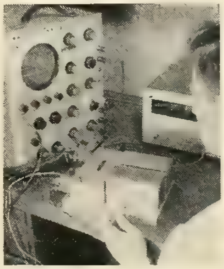


PAYLOAD section of *Discoverer I* including Bell's Hustler engine has 19 ft. length (p. 20).

ARMY's *Pioneer IV* just prior to launch at Cape Canaveral for orbit about the sun (p. 20).



MONOPROPELLANT research is getting stressed at Wyandotte's Michigan facility (p. 23).



ASCOP follows new modular concept for design of telemetering equipment (p. 43).

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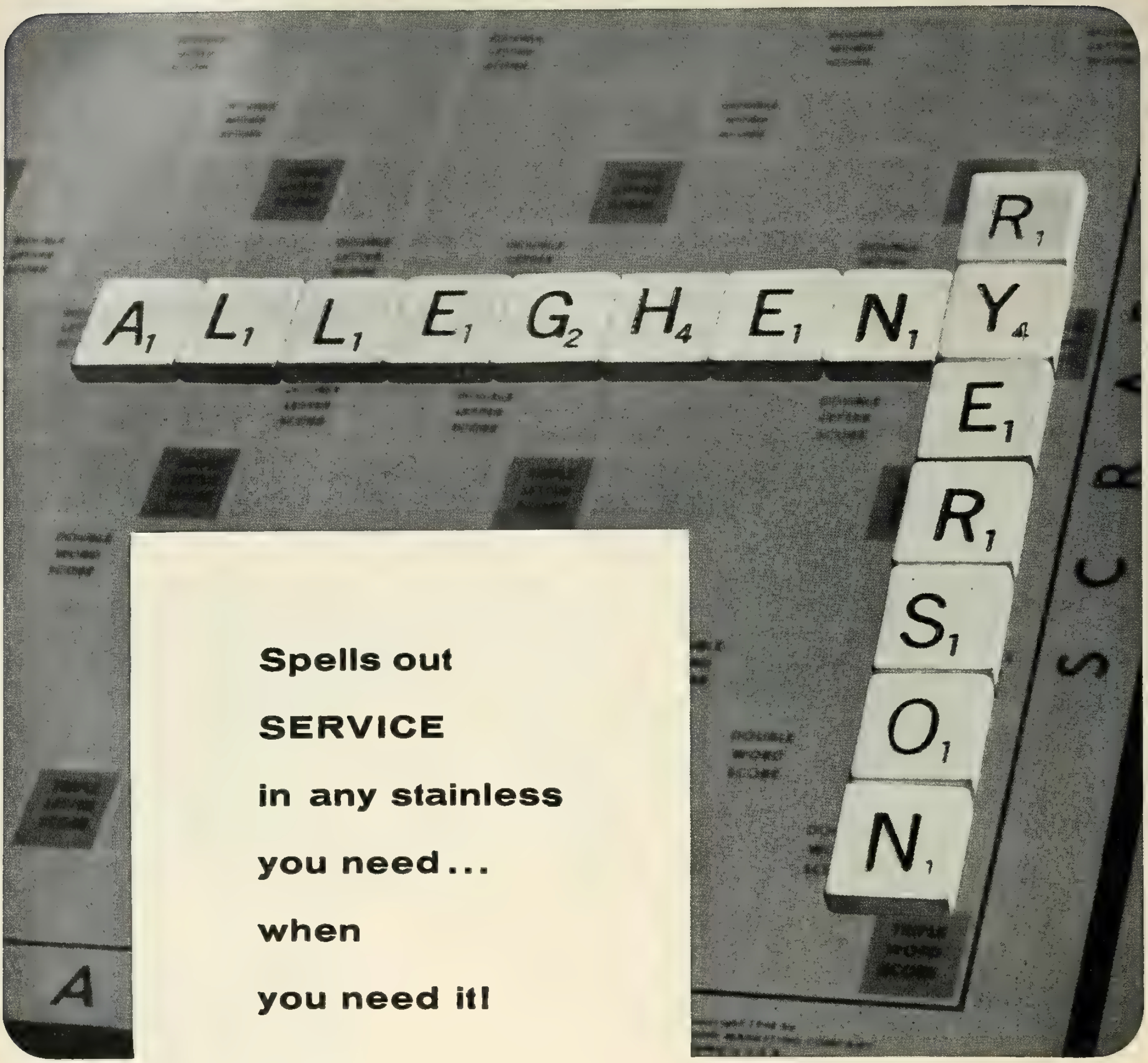

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HETS Program: Space Cooperation

One of the brightest spots to show up in the nation's space exploration picture appears in the form of the present cooperation between the National Aeronautics and Space Administration and the Department of Defense in the development and production of two parallel programs—NASA's *Scout* project and the S-609A enterprise of the Air Force. Combined, the two will be known as HETS—Hyper Environmental Test System.

We recently mentioned in this space that the head of ARPA had announced to his somewhat amazed staff and the military services that in the future NASA would undertake the development of all powerplants for space exploration, civilian and military. We thought, and still think, that inherently this could be dangerous in that the very real needs of the military might be delayed or lost in the zeal for peaceful space activities; that, however, the old NACA and the military had a fine record of working together and that this could and must be continued between NASA and the services.

Now in the HETS program—just announced or just about to be—comes a degree of cooperative understanding that is heartening indeed. The facts are these:

NASA needed a cheap, four-stage vehicle *(Scout)* which would loft payloads on the order of 50 pounds, either for space exploration or to be placed in orbit. NASA wanted it for general purpose tests in high-altitude environmental soundings.

The Air Force wanted approximately the same vehicle (S-609A) for re-entry testing, to perfect a profile for the space missile platform *Dyna-Soar* and for checking various components for temperature, radiation resistance, stability and posture.

Under the present arrangement NASA will contract for the hardware. Some bids have already been requested. The vehicle will be four-stage with its components either developments of presently existing hardware or some second generations of that presently existing. For example, the first stage could very well be closely akin to the solid-fuel *Sergeant*. For NASA use the vehicles can be simple and unsophisticated.

The Air Force will need a somewhat higher degree of accomplishment in its vehicle—certainly more guidance including perhaps gimballed motors. But, since the AF and NASA worked together on the specification, this extra equipment can be built during the 18 months or so required to produce the basic booster and can be added with a minimum of delay. NASA will be doing its testing at Wallops Island and the Air Force at Cape Canaveral or Vandenberg.

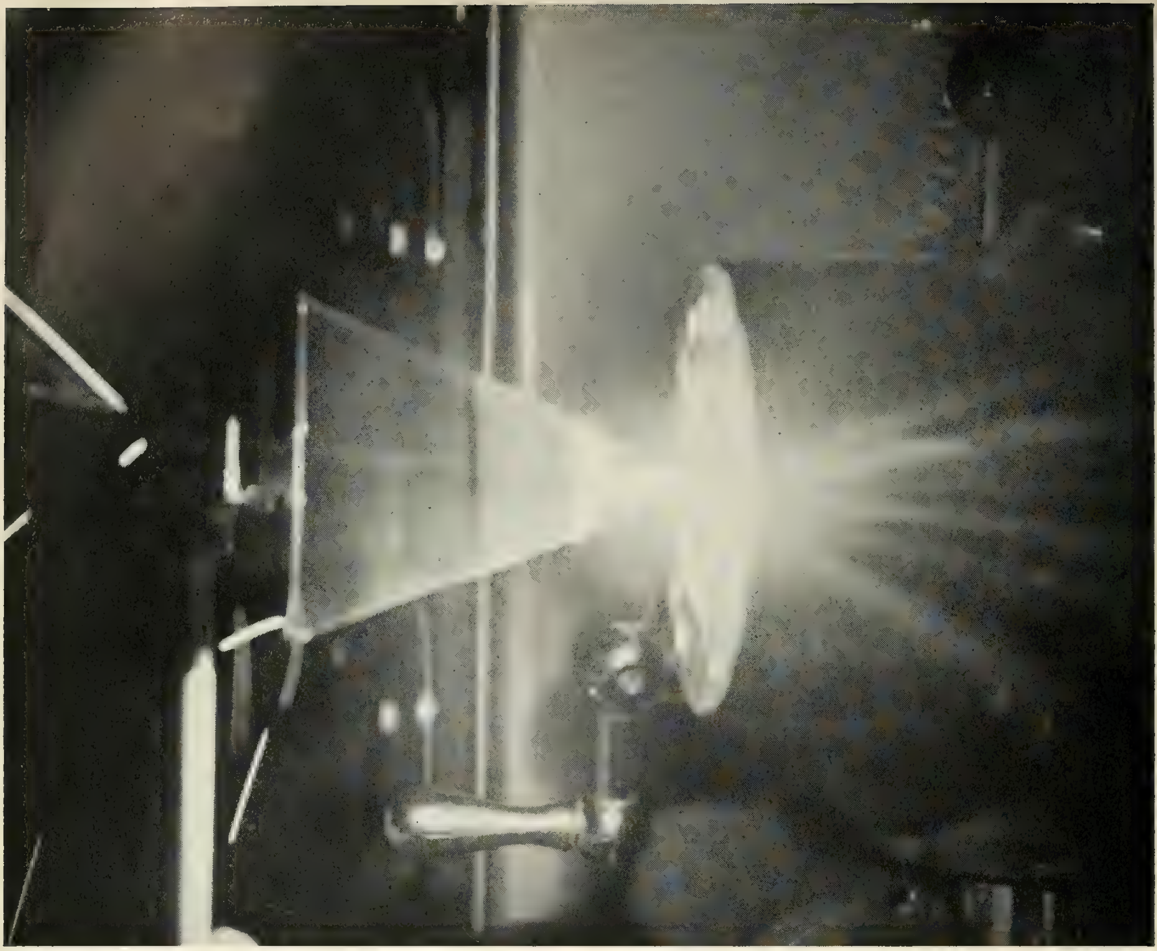
This is a fine example of what can be done in the country's space program, and not entirely typical. In the U.S. space setup as it now stands, three services and several governmental agencies or offices have split the responsibility and the authority for producing a military and peaceful program which will ensure our at least equality in the vast and new field of space exploration. The result is at least confusing. It could be disastrous.

There are two many bosses, too many agencies and too many fingers in the pie; too many jealousies, too much in-fighting, too much politics. If the U.S. space program suceeds—it may be in spite of itself. At least the HETS program is a hopeful sign in that direction.

Here, two agencies of the several involved had a need for approximately the same hardware to carry out parallel test programs. The officials in charge got together, agreed on a cooperative plan, worked out the details and went to work. Bless them.

This joint enterprise will save the country money, scarce talent and probably time. It may even establish a precedent which other agencies could follow. It could allow a unified program with a common goal—something we have not had before.

Clarke Newlon



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New Plasmatron at Solar helps solve difficult super-heat problems

EXTREME HEAT presents a formidable barrier to the advancement of missile and nuclear technology. Solar is helping to push back this thermal barrier by controlling temperatures higher than those of the surface of the sun...for advanced research in high-temperature problems.

Solar's new Plasmatron, above, is a device which generates heat to 30,000 F at ordinary atmospheric pressure. It is opening new fields of research in aerodynamics, radiation, metallurgy, chemistry and in the testing and application of high-temperature materials and coatings. In addition, the Plasmatron is used in wind tunnel studies and in other fields of research.

For more than three decades Solar has been a leader in high-temperature technology. Today Solar is applying its background of knowledge and experience in creating missile nose cones, rocket chambers, nuclear components and other products for high-temperature, high-stress requirements. This know-how and experience—plus a continuing program of creative research—is available for your important missile or nuclear program. For details write to Dept. F-124, Solar Aircraft Company, San Diego 12, California.

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washington countdown

NATO nation interest . . .

in *Lacrosse* is picking up. Could it be because it will become operational with U.S. troops at Huntsville and Fort Sill on June 1, or is it because in a nine-mile firing last week at White Sands miss distance was nine feet—one foot a mile?

Speaking of operational . . .

U.S. missiles, Navy's *Bullpup* joins the Pacific fleet next month, with a target data for *Mace* of about June.

Mrs. V is follow-up . . .

and a new name from MIS (maneuverability in space) of the *Discoverer* project. Main purpose is bio-med studies.

Even competitors say . . .

GE has the "track" for Army's Missile *Able*. Still running strong in the competition which is up now for JCS review and a decision after July 1 (budgetary consideration) are Martin, Cornell Aeronautical Labs, Armour Research Foundation, Douglas, and Minneapolis-Honeywell. *Mauler* (Sperry Rand, GE Convair and Martin) will await a decision after July 1, too. But *Dyna-Soar* and *Bold Orion* (WS-199B) will be decided about May 1.

Selection of Philip B. Taylor . . .

as assistant secretary of Air Force for Materiel came after several weeks of screening half a dozen or more prospects. A PhD in mechanical engineering, Taylor has been with Sanderson & Porter, New York management engineers, since 1947, served previously in the Pentagon as consultant for Defense R&D.

May we suggest . . .

the code name of *DOT* for a submariner's small missile to knock down *DAT* (the drone assisted torpedo) which was heavily emphasized at Navy's Seapower Symposium in Washington last week. It would be a good companion for *DASH* (helicopter-launched A/S homing missiles, with Republic a good contender). Symposium, incidentally, echoed with rumors that Navy plans to fire *Lulu* from an 8" gun. Publicly, Navy said it wants industry in the next 10 years to produce a triple-purpose missile: anti-aircraft, SAM, and anti-submarine.

Congress may override . . .

previous Pentagon and Administration moves affecting the *Nike-Zeus* production go-ahead. An indication may be in Defense Secretary McElroy's statement to Congress that the Pentagon now is considering the possibility of beginning some sort of "pre-planning production program." It's estimated that *Zeus* will cost $7.5 billion to produce. Army says now's the time to go ahead with preparation of plants and tooling for production. However, McElroy says his best scientists have told him that *Zeus* is not at this stage.

Venus firing dates . . .

given out by Rep. Overton Brooks in a television interview last week match dates given by m/r months ago. On June 3, Brooks said, an *"Able IV Thor"* would carry a 78-pound payload to the vicinity of the planet, and on the following day an *"Able IV Atlas,"* would try to orbit a 325-pound payload around Venus.

Expanded research . . .

into high-power microwave radar is planned by Cornell Aeronautical Laboratory with receipt of a $1.3 million Army Ordnance contract. The laboratory has a two-fold objective: experimental investigation into the means and techniques for radiating very high peak microwave radar power; and investigation of propagation phenomena, possibly for ICBM detection. Cornell originally had a $200,000 research contract in this field for Project *Plato,* and successfully transmitted 21 million watts of peak power without electrical breakdown. New research will be aimed at 50 million watts.

And incidentally, *Plato* . . .

was dropped, Maj. Gen. J. B. Medaris told Congress, after $18.5 million was spent on the project. He indicated action was taken on a higher level because of budgetary considerations.

Contractors will get chance . . .

to speak out on NASA's temporary rules governing waiver of Government patent rights under the agency at a public hearing in Washington, May 18. Those wishing to appear must advise NASA by May 1; however, written briefs can be filed within next 60 days. As a matter of policy, waivers will be granted where the stimulus of ownership of patent rights will encourage the contractor to more speedily develop an invention to the point of practical application.

...NEWS IS HAPPENING AT NORTHROP

RADIOPLANE RP-77D SETS NEW DRONE ALTITUDE MARK!

New holder of an unofficial world altitude record for propeller-driven drone aircraft – Radioplane's RP-77D aerial target. This record-breaking bird climbed to more than 46,000 feet during Army evaluation at Dona Ana Range, Fort Bliss, Texas.

Sidelight on the flight: the record-setting drone had six previous flights to its credit – is ready for further action after its seventh recovery by two-stage parachute.

Rocket launched, Radioplane's RP-77D is turboprop powered to speeds in excess of 400 miles per hour at above 40,000 feet – and is capable of flight duration exceeding one hour at this altitude. Relative to performance, it is a low-cost target. Constructed almost entirely of fiberglass laminate, the RP-77D has an additional capability for photo and television combat surveillance missions.

Other current Radioplane drones in development are the supersonic USAF XQ-4A weapon evaluation target and the XKD4R-1 rocket target for the U.S. Navy – two more members of the world's only complete drone family.

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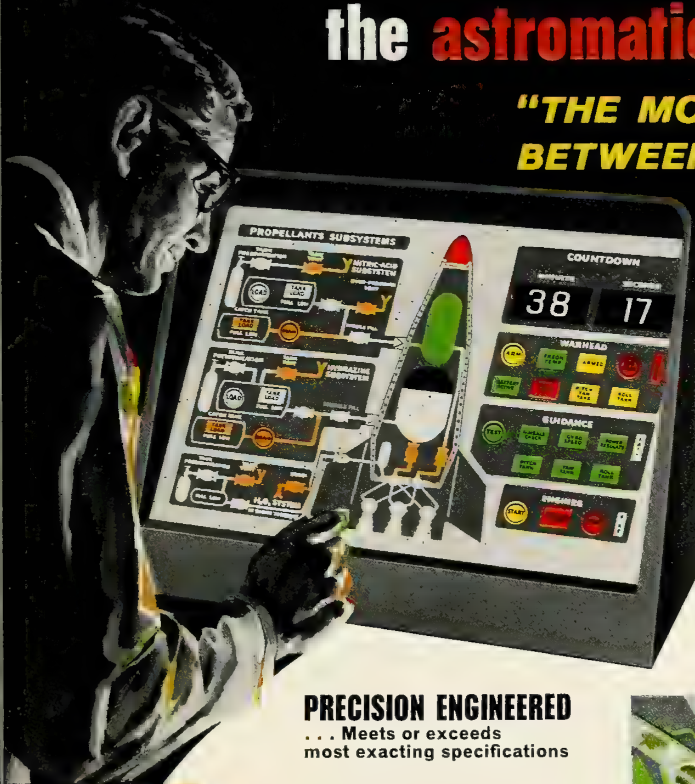

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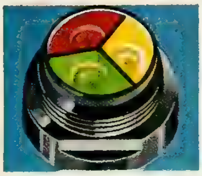

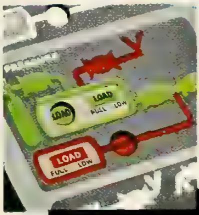

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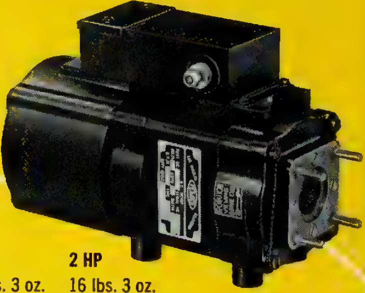
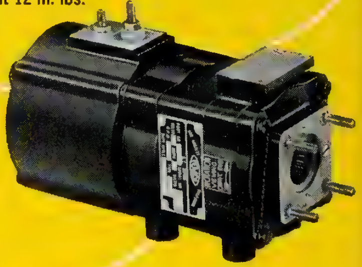
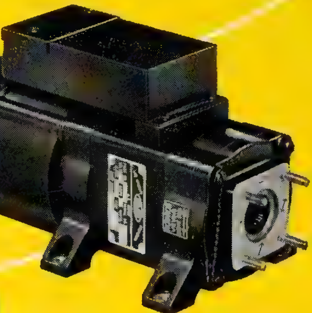


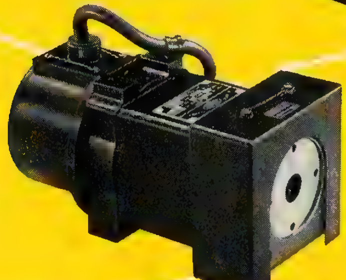
Type D-1082	**4 HP**	**2 HP**
Weight:	16 lbs. 3 oz.	16 lbs. 3 oz.
Motor Torque:	25 in. lbs.	12 in. lbs.
R.P.M.:	10,000	10,700 (approx.)
Terminal Voltage:	27 volts DC	27 volts DC
Operation:	In a period of 34 minutes: any 4 min. @ 25 in. lbs., balance at 12 in. lbs.	



Type D-1082-1	**4 HP**	**2 HP**
Weight:	13.87 lbs.	13.87 lbs.
Motor Torque:	25 in. lbs.	25 in. lbs.
R.P.M.:	10,000	11,500
Terminal Voltage:	27 volts DC	27 volts DC
Operation:	2 minutes max. @ 25 in. lbs. plus 10 min. max. @ 12 in. lbs.	



Type D-1029-1	
Weight:	20 lbs.
Horsepower:	6 HP
R.P.M.:	7500
Terminal Voltage:	26.6 volts DC
Duty Cycle:	4.5 HP for 7.5 minutes 6.0 HP for 20 seconds 2.0 HP for 30 minutes



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industry countdown

Navy's *Eagle* missile program . . . is getting a thorough going-over. Main purpose is try to hold down costs on the air-to-air missile. Final list of sub-contractors has not been approved by the Navy and will be forthcoming before the green light is given the prime contractors, Bendix-Grumman.

Canadian firms have been asked . . . to bid on more than 100 items of the *Bomarc* weapon system. First of these contracts is $1.7 million to Canadair for *Bomarc* wings and ailerons. Announcement came from L. A. Wood, Boeing vice president and general manager of its Pilotless Aircraft Division. Wood said that many Canadian firms should be able to bid competitively with domestic industry on the high-precision work required in the *Bomarc* missile program.

Missile and aircraft R&D . . . employ more scientists and engineers percentage-wise than any other manufacturing industry, a recent National Science Foundation survey revealed. The aircraft/missile and parts industry employs about 67% of its 84,900 scientists and engineers in R&D projects. Sixty-two percent of the industry's 51,500 technicians are engaged in R&D compared to the average of 27% employed in R&D by all other major industries.

***Jupiter*'s ground equipment . . .** will be produced by Chrysler Corp. under an Army contract amounting to $20,944,039.

200 flights of RJ43 ramjet . . . have been completed in operations on the Boeing *Bomarc*, Lockheed Kingfisher, and Lockheed X-7, a flight program released by Marquardt Aircraft Co. recently revealed.

Two full-scale propulsion reactors . . . and seven military reactor prototypes went critical during the last six months of 1958, according to the semi-annual report of the Atomic Energy Commission. The AEC also reported progress in developing reactors for use in unmanned vehicles. These include those for *Rover* (non-nuclear parts have been transferred from Air Force to the National Aeronautics and Space Administration), *Pluto*, and Project *Snap* to provide nuclear auxiliary power for space satellites.

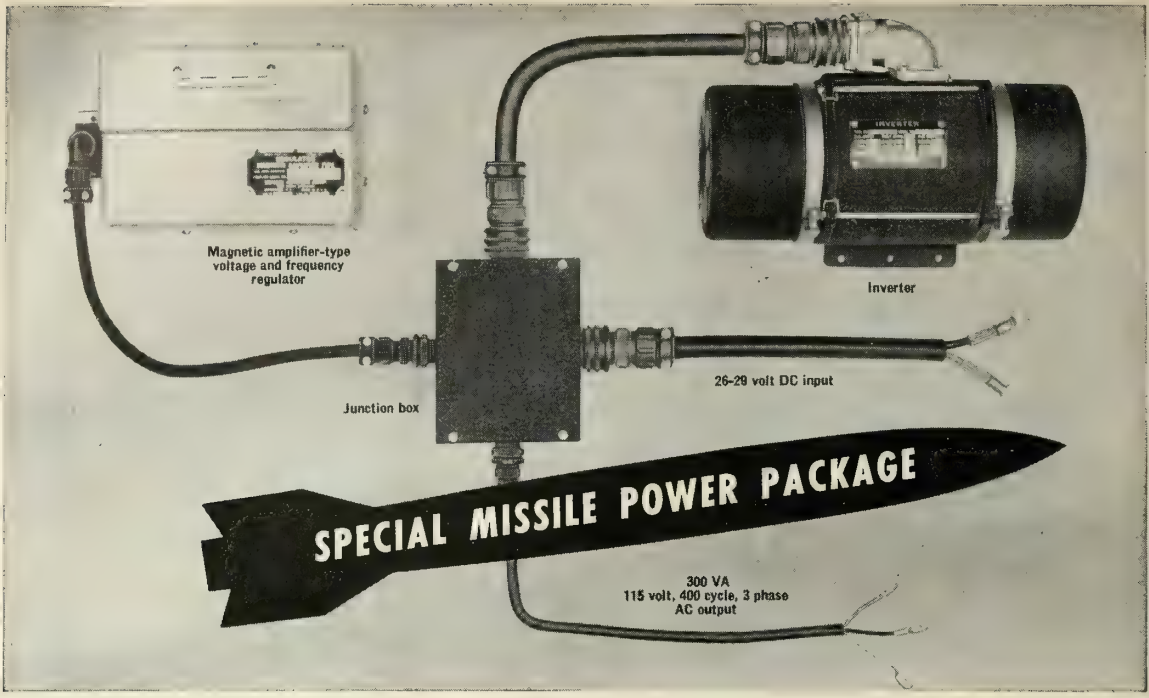
Solid fuel elements . . . and a gaseous propellant are used in developing *Kiwi-A*—the initial test vehicle for Project *Rover*—and to demonstrate feasibility of nuclear rocket propulsion. Work is being done at the Los Alamos Scientific Laboratory. *Kiwi-A*, which uses a relatively low-power experimental reactor, was assembled without nuclear components by ACF Industries, Inc., at the AEC's South Albuquerque Works Plant and reassembled at Nevada Test Site with nuclear components.

AEC reported . . . encouraging results in materials research by the Atomics International Division of North American Aviation in connection with Project *Pluto*. Initial data on high-temperature materials have been extended to include the effect of fuel additives. AEC points out that a nuclear ramjet, such as being developed under *Pluto*, could propel missiles with unlimited ranges within the earth's atmosphere. Atomics International also is the contractor on *Snap-II* which uses a nuclear reactor as a heat source to operate a generator for nuclear auxiliary power source in space. *Snap-I*, under development by The Martin Company, will use heat from a radioactive isotope to operate electrical power conversion equipment.

New hose can handle 600 degree . . . temperatures for short periods. Developed by the Thermoid Division of the H. K. Porter Company, Inc., the hose is made of Dupont "Viton," and lasts almost indefinitely at 350 degree temperatures. The hose also has high abrasion resistance and resists extremes of chemical attack.

500,000 unit production increase . . . has been reported by Tri-Point Plastics Inc., for the month of January. The company specializes in "Teflon" plastic components for the electronics and missile fields.

Kollsman Motor Corp. . . . has been formed as a wholly owned subsidiary of the Standard Coil Products Co. Inc., to produce precision electrical motors for the aircraft and missile industry.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(Incorporate Static Type Controls)

Type	Input		Rated Output			Max. Altitude at Rated Output	Approx. Wt. Lbs.	Designed to Gov't. Part No.
	Volts	Amps.	Volts	Phase	VA Rating			
32B92	27.5	126	115	1 3	1500 1800	20,000	37	—
32B81	27.5	100	115/200	3	1500	Unlimited	65	—
32B77	27.5	180	115/200	3	3000	Unlimited	75	—
32B79	27.5	400	115/200	3	7000	Unlimited	115	—
32B76	27.5	20	115	3	500	70,000	25	—
32B122	27.5	150	115/200	3	2500	50,000	65	—
32B41	27.5	150	115/200	1 3	2500 3000	50,000	68	—
32B52	27.5	35	115/200	1 3	500 500	40,000	25	—
32B106	27.5	95	115	3	1400	35,000	44	—
32B27	27.5	285	115/200	1 3	3500 4000	50,000	76	—

GENERAL PURPOSE INVERTERS—400 CYCLE OUTPUT

Type	Input		Rated Output			Max. Altitude at Rated Output	Approx. Wt. Lbs.	Designed to Gov't. Part No.
	Volts	Amps.	Volts	Phase	VA Rating			
12128	27.5	1	26	1	6	35,000	2.2	AN3496
12126	27.5	2	26	3	10	35,000	2.3	E1615
MG-54	27.5	22	115/200	1 3	250 250	50,000	17	E5109
12142	27.5	22	115	1 3	250 250	35,000	13	E1617
12143	27.5	22	115	3	250	35,000	13	—
32E01	27.5	35	115	3	500	50,000	26	AN3533-1
32E00	27.5	51	115	1 3	500 750	50,000	34	AN3534-1
MG-65	27.5	52	115/200	1 3	750 750	50,000	35	E52805-2
MG-61	27.5	126	115	1	1750	50,000	54	53C6767
1518	27.5	126	115	1 3	1500 1800	20,000	37	—
32E06	27.5	160	115/200	1 3	2000 2250	50,000	56	E1725
32E03-3	27.5	150	115	1	2500	50,000	58	53B6227
32E03-9	27.5	160	115/200	1 3	2500 3000	50,000	58	E54807
32E09	27.5	160	115	1 3	2500 3000	50,000	60	—

Red Bank Division **Bendix** AVIATION CORPORATION

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World Rapidly Adding More Missile Ranges

United States is negotiating in hopes of cooperation in man-in-space plans. Existing ranges vary from relatively small facilities to those extending thousands of miles. Small nations are participating at a fast-growing rate.

by William O. Miller

WASHINGTON—The United States is negotiating with a number of other governments for joint participation in space research. These discussions, m/r has been told, are being pursued with the hope that the world's rocket and missile ranges—with or without Soviet participation—will be used cooperatively for man-in-space.

Dr. T. Keith Glennan, top man in the nation's space administration, already has expressed U.S. willingness to participate in a joint satellite venture with Great Britain and the USSR. Meanwhile, the State Department is negotiating with Britain and Australia for permission to put tracking stations in the Admiralty Islands to the north of New Guinea and on Christmas Island in the Indian Ocean. The Christmas Island facilities would also serve as an extension of Australia's Woomera range.

The negotiations are important in the development of an adequate detection and identification system for defense of the free world. Of high priority also is mutual use of the world's rocket ranges—first for worldwide space communications and tracking, and later as launch sites for manned space vehicles.

As a service to m/r readers, the following comprehensive listing of the more important known missile and space test ranges has been compiled. There is considerable doubt about some of the reported ranges in the Soviet Union, Red China and Russian satellite nations.

• **Wide variety**—Although many of the world's ranges are relatively small in size, some of them spread over tens of thousands of square miles of the surface of the earth. Others probe long slender fingers thousands of miles out to sea.

Two interesting facts concerning them are that unclassified trade literature and other journalistic publications indicate they are so numerous, and that the investment in instrumentation and other features represents literally billions of dollars.

Vital to evolving national defense programs and to the exploration of the vertical frontier, these ranges have come into existence in recent years as dramatic landmarks of the mushrooming expansion of the human horizon.

• **Small nations, too**—A rapid survey of English-language books and periodicals establishes that even many of the smaller nations of the world are developing missile test ranges. In addition to the United States and the Soviet Union which, of course, have many such facilities, the random survey has produced information on missile and rocket ranges and research-vehicle launch sites in many parts of the world.

Included are those in Algeria, Argentina, Australia, Brazil, Canada, mainland China, France, Germany (both East and West), the Hebrides, the Indian Ocean, Japan, Korea, Libya, Poland, various Pacific islands, Sardinia, Scotland, Tibet and Wales, plus oceanic shipboard launchings in the waters of the Arctic, Antarctic, Atlantic, and the North, Central and South Pacific.

• **Australia**—One of the largest research and development test ranges in the world is the famous Woomera Range in Australia. Its origin dates from a survey in 1946 by a joint United Kingdom-Australian mission, and it was actually established as the Long Range Weapons Organization in 1947. The ultimate decision for this location was based on good visibility throughout the year, and opportunities for observing and recovering the missiles.

The range extends from Woomera in south-central Australia to the northwest coast, a distance of between 1100 and 1200 miles.

Recently, in anticipation of heavy IRBM testing, the width of the range has been increased to include many additional thousands of square miles. The joint United Kingdom-Australian program has been extended another five years. Plans are to more than double the length of the range by extending it on across water to Christmas Island in the Indian Ocean, for a total distance of 2700 miles.

Woomera is a proper name for this gigantic range. It is the aboriginal name for the launching device used by Bushmen to speed a spear toward its target.

Woomera's geographic conditions and testing advantages are strikingly similar to those of the White Sands Missile Range, and there have been many exchange visits of groups from these two major ranges. Although Woomera is inconveniently located some 12,000 miles from its primary source of missiles and rockets, the testing of drones, ramjets and ballistic missiles, among other projects, continues. So does the launching of rockets for upper atmospheric research.

The Christmas Island terminal of the Woomera range has had other research and development uses. In 1957 the two hundred civilians living on the island were evacuated to permit British hydrogen bomb testing.

• **Canada**—The best known research work using rockets in Canada has been the active IGY program at Fort Churchill. This is a joint scientific program of the Canadian and United State governments. Army troops of both nations, as well as industrial representatives and scientists from both sides of the international border, have participated in this program. There have been as many as twenty consecutive successful firings of *Aerobee*, *Aerobee-Hi* and *Nike-Cajun* rockets, and possibly longer records have been established including the use of other types of research vehicles.

With the IGY facilities constructed

largely by the United States Army, this installation is located in Manitoba, near Fort Churchill, midpoint on the western side of Hudson Bay. The site was partially developed by the Canadian Army, whose missile launch crews had tested *Nike* missiles there under 35°F-below-zero weather conditions as early as the winter of 1954-1955.

Elsewhere in Canada there are test facilities for guided weapons. The Canadian Defense Research Board and the Royal Canadian Air Force, for instance, test air defense missiles at the Cold Lake range in Alberta.

• **French ranges**—Most missile testing by the French takes place at Colomb Bechar, deep in the Algerian Sahara. This major North African range has been in existence about ten or eleven years. Its primary work has centered about the testing of surface-to-surface and surface-to-air missiles, although some development testing of high-altitude research rockets has taken place.

Colomb Bechar, beyond the Atlas mountains, is located not far across the southern border of French Morocco into Algeria. Like many other major research and development test ranges of the world, its facilities have been made available for an international workload. Because of the unstable domestic and international political situations in North Africa, however, other European spokesmen have expressed the desire that NATO IRBM ballistic missile testing be accomplished elsewhere.

Some testing is done within France itself. One range which has been used for testing ramjets and shorter-range missiles, exists near Cannes on the Mediterranean. Undoubtedly there are other such facilities elsewhere within the country.

• **German ranges**—Within both East and West Germany there appears to be activity in missile research and development. Much of the World War II weapon system testing was done at Peenemunde, on the Baltic, and at the Blizna firing range, in Poland. There are many indications that Soviet scientists and technicians have long since reactivated the test and other facilities at Peenemunde.

West Germany's principal launch site is located near Cuxhaven on the North Sea. IGY rocket launchings were planned to take place from here. There has also been activity near Luneburger Heide, northeast of Hanover, and near Bremen, where the active German Rocket Society carries out an interesting research and development test program.

• **Great Britain**—Without question, the British have the most ambitious missile and space technology program in the world, other than those of the United States and the Soviet Union. They are moving forward on every front, including research in the human factors of space flight. In the early autumn of 1959 they will host in London the Tenth Congress of the International Astronautical Federation, the first of the Big Three nations in space technology to have this honor.

British research and development testing of rockets and missiles is carried on in several places. In addition to making extensive use of the huge Woomera establishment in Australia and possibly other NATO ranges, they have test ranges located in Wales, Scotland and the Hebrides. They have even tested radio-controlled target drones in North Africa.

Even before the Woomera range became available, the test range at Aberporth, on the coast of Wales, was the scene of considerable activity. This range has since continued in heavy use for testing air defense missiles and ground-to-air weapon systems. One of the greatest disadvantages of the Aberporth range, according to the British, has been the fact that the overwater flights have all but eliminated the possibility of recovering test missiles after impacting or recovering the bits of the target itself to determine the lethality of the warhead burst.

Meanwhile, other testing is conducted on a small missile range on the Solway coast of Scotland. Much of the workload here appears to be missile weapons for use by ground forces. There are also indications that this facility will be used for launching high-altitude research rockets and limited ICBM component testing.

Recently Great Britain annexed Rockall Island near the Hebrides in the area of a new test range now under development. The main installations are going into the South Uist area, with primary instrumentation established on the island of Hirta. Other instrumentation is being installed in the lonely St. Kilda island group of the Outer Hebrides, on the flank of the firing range. This range, when fully operational, will materially assist the expanding British research and development program.

• **Japan**—The Japanese appear to have at least three test ranges where experimental flights take place. One is the Michikawa rocket center in Akita Prefecture, northwestern Honshu. From there Japanese scientists and engineers from Tokyo University's Institute of Industrial Science have tested research rockets for IGY use, firing toward the Japan Sea. Recent successes here have climaxed a three-year program of rocket development.

Military missile testing is conducted elsewhere. One range is the Ojoji Proving Ground in northeastern Japan. The testing of military missile systems began here with the firing of the first post-war Japanese military missile on July 24, 1956. The Somagarah range in central Japan became operational about 1957 for missile work, and other weapon systems have been tested there.

• **Other Nations** — Interest in rocketry and space technology, official or otherwise, has given rise to considerable activity in many other nations of the world.

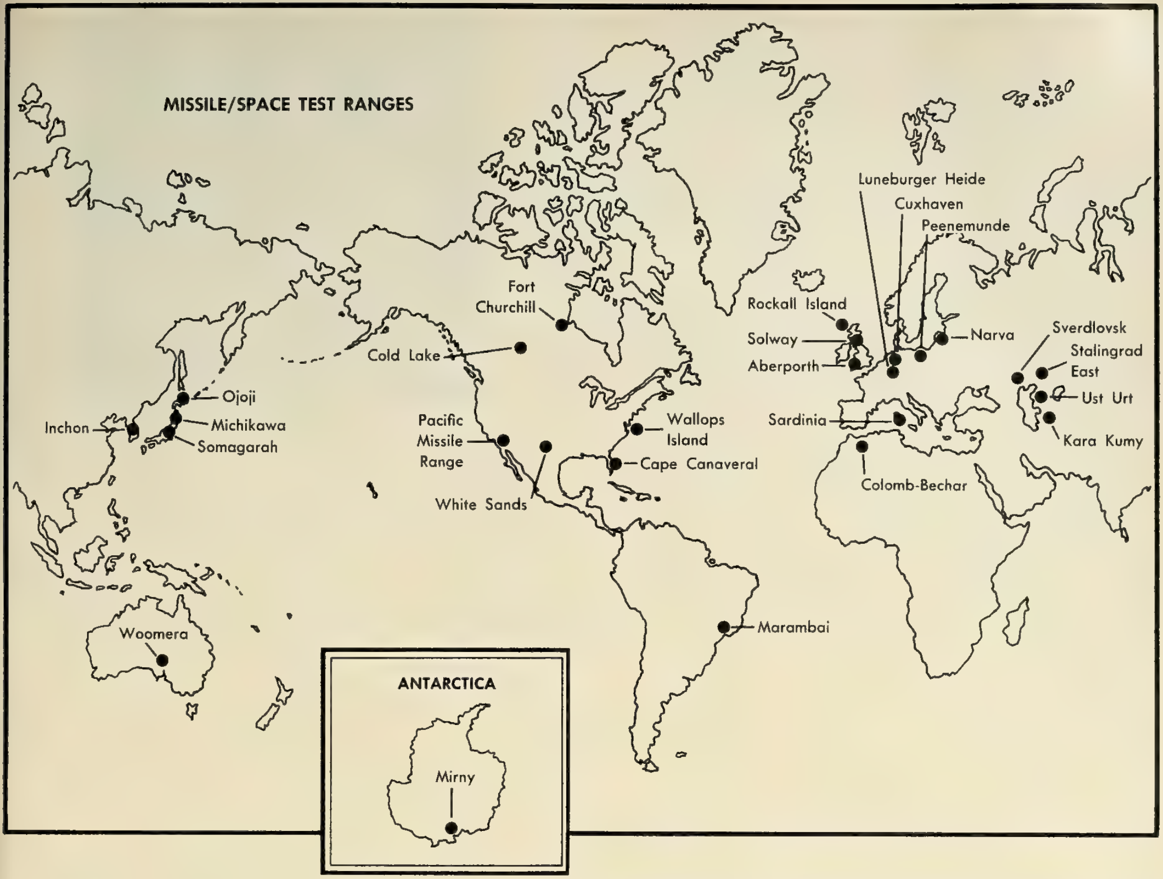
In South Korea, for example, the government has only recently expressed interest in the development of missiles. The National Defense Scientific Research Institute of that country has successfully launched its first experimental guided rocket in a test firing near Inchon, some twenty miles west of Seoul. Non-official interest in rocketry on the part of South Koreans has led to efforts to secure recognition from the Ministry of Education for a Korean Astronautical Society.

Italy has been much more active in missile research and development, and the Italian government has established a full-fledged missile test range on the Mediterranean island of Sardinia. The main instrumentation complex and administrative headquarters are located at Cagliari, where a large aircraft control and warning station is in operation.

A variety of projects have already been tested on this range, principally air defense and ground-to-air missiles. Because of the political situation in Algeria, the Italian government has proposed the use of the Sardinian range instead of Colomb Bechar for NATO intermediate-range ballistic missile testing. This may occur, although the Ralph M. Parsons Company, of Los Angeles, has undertaken a survey of possible sites for missile test ranges in several NATO countries under a contract from NATO's Advisory Group for Aeronautical Research and Development.

In Brazil, too, the government has established a modest program of research and development related to rocketry and space biology. Best known is the Brazilian Army's project involving lofting an animal payload into the region above seventy miles. The launch site for this activity is at Marambai, across the bay from Rio de Janeiro.

The Argentines have had an active Asociacion Argentina Interplanetaria for many years, one which has even given courses on rocketry and satellites within the Science Faculty of the University of Buenos Aires. Recently the Instituto de Investigaciones Cientificas y Tecnicas de las Fuerzas Armadas



THE WORLD's known rocket ranges circle the globe and extend from Canada and the Hebrides to a Soviet base in Antarctica.

conducted an exhibition of various missiles both for aviation and ground use, although nothing has been learned concerning the missile range upon which these have been tested.

• **Russia**—Public information concerning activities in countries within the Soviet sphere of influence is more difficult to obtain. Nevertheless, there are indications that considerable activity is going on in several of those countries, much of it supported directly by the Soviet Union. The reactivation of Peenemunde, mentioned above, is one example.

In Poland the large Polskie Towarzystwo Astronautyczne and the Rocket Section of Krakow's Metallurgical Academy are developmentally testing multistage meteorological rockets. The Chinese Communist government, too, appears actively interested in rocketry and space technology, although their ambitious comments on these subjects have produced no hardware which has come to the attention of this survey.

It is within the Soviet Union, itself, that one of the world's two major programs of weapon system development and astronautical scientific research is being pushed with tremendous priority. There are persistent rumors that the Russians have set up a launching site on a Tibetan plateau to take advantage of the high altitude. While this would be an excellent location for any missile and space work the Soviets might be carrying out jointly with the Communist Chinese, the logistical problems would appear to be almost overwhelming for a program of any size.

While details are unavailable, the Russians are known to have missile and space vehicle launching sites in the Ust Urt and Kara Kumy desert regions to the east of the Caspian Sea. Additional test centers are located near East Stalingrad and in the north near Narva, just to the west of Leningrad.

Launching bases are numerous around industrial centers, particularly in western Russia. While many of these are sure to be air defense type launching sites, they also are presumed to include a number of IRBM bases. Additional missile launching sites are reported in the north of Siberia and others as far east as Sakhalein and the Kamchatka peninsula.

The Russians also have indicated they plan to launch rockets at the other end of the earth—Antarctica. Alexander Nesmyanov, President of the USSR Academy of Sciences, has said Russia eventually will launch satellites from Mirny, its large and permanent base on the southern polar continent. Russia also has announced that it expects to launch some 30 rockets from Mirny as part of its contribution to the International Geophysical Year.

• **U.S. effort**—Inasmuch as coverage of the U.S. missile and space effort is large part of the mission of m/r, only mention of major bases will be made.

The two main sites are, of course, the Atlantic and the Pacific Missile Ranges. Additional testing is carried out at the White Sands range in New Mexico and more tests are being scheduled for the Wallops Island test range on the Atlantic coast of Virginia, a facility now operated by the National Aeronautics and Space Administration.

Anderson Promoted From ARDC To Head AMC

Popular commander becomes a contender for chief of staff after hectic but rewarding efforts to speed missiles.

by James J. Haggerty, Jr.
Contributing Editor to m/r

WASHINGTON—This month the Air Force's Air Materiel Command, which spends more than $8,000,000,000 annually with U.S. industry, gets a new boss.

General Edwin W. Rawlings, who earned the respect of the aircraft and missile manufacturing industry for his efficient administration of AMC over the past several years, is stepping down from the important post to retire. His replacement is Lt. Gen. S. E. ("Sam") Anderson, who has served as commander of Air Research and Development Command for the last 19 months.

With his advancement to the higher-ranking command comes four-star rank for Sam Anderson, subject to Congressional sanction. His is a new name which must be added to the roster of "possibles" in the popular guessing game, "Pick the Next Chief of Staff." In view of announced and anticipated retirements among the USAF hierarchy, Anderson will be one of a half-dozen top contenders.

Despite his high ranking, Sam Anderson is a comparative unknown. He is not even as well known as some of his subordinates in ARDC, such as Maj. Gen. Bernard A. Schriever, his deputy commander for ballistic missiles, whose job has exposed him more frequently to the public view. Anderson's relative lack of publicity stems largely from personal reluctance to face the glare of the national spotlight. "I'm not a very interesting guy," he says.

His own view to the contrary, Sam Anderson is a very interesting guy, particularly to the thousands of contractors who do business with his new command.

- **Left artillery**—At 53, Anderson already has close to 33 years commissioned service, plus an additional four in the U.S. Military Academy. He became a second lieutenant in the Coast Artillery upon graduation from West Point, but he never got around to serving in that branch. Instead, he went to Brooks Field, Tex., to take up flying training.

After the usual succession of instructorships and operational jobs, Anderson, then a colonel, landed on the War Department General Staff in the early days of World War II. In early 1943, he shipped to the Pacific and saw brief combat action there—just long enough to win a Silver Star. Later the same year, he turned up in the European Theater of Operations and flew a number of missions as a wing commander, adding the Distinguished Flying Cross to his growing list of decorations.

In October, 1943, he became commanding general of the IX Bomber Command of the IX Air Force, and stayed in that post until the end of the war in Europe.

- **After the war**—His post-war service was equally distinguished. He was named a member of the Joint Strategic Survey Commission in 1946 and two years later became Director of Plans and Operations under the Deputy Chief of Staff/Operations in the Pentagon. In 1950, he was placed in command of the Eighth Air Force (SAC) at Carswell AFB, Texas.

In May, 1953, he returned to the Pacific area for another tour of combat duty as commanding general of the Fifth Air Force in Korea. Again it was a brief tour, since the Korean "police action" was stalemated less than two months after he assumed command, but he had the satisfaction of seeing his forces rack up a record of 74 kills in the month of June, highest monthly total of the war, including the Korean action's record day in which 15 MiG's were destroyed.

Returning to the United States the following year, Anderson took over the important post of director of the Weapons Systems Evaluation Group of the Department of Defense. In this job he displayed a talent for tact and diplomacy and his tour as director was marked by an uncommon harmony among the members of the group, who represented different services and held varying opinions as to the proper conduct of a potential war.

"He handled the job so well," says one of his top assistants, "that even the Navy was sorry to see him leave."

- **Pre- and post-*Sputnik***—He left WSEG to take over Air Research and Development Command on Aug. 1, 1957, just 64 days before the Soviets launched their first *Sputnik*. His 19 months as commander on ARDC were hectic ones. In the brief pre-*Sputnik* period, he had to battle an Administration-imposed economy wave with its attendant ceiling on expenditures. In the months that followed the *Sputnik* furore, he had to accelerate everything, but with still far-from-unlimited funds.

His record for that trying period is an excellent one. Despite the overpublicized failures of some missile projects, a number of important weapons were brought into operational use or to near-service status. The Convair *Atlas*, for instance, is now several months ahead of its pre-*Sputnik* schedule.

Anderson's ARDC administration also brought into being or revived and accelerated such important projects as the solid fuel *Minuteman* ICBM, the hypersonic B-70 missile platform, the F-108 interceptor, the *Dyna-Soar* orbital bomber and one of Anderson's pet projects, the air-launched ballistic missile.

- **ALBM pushed**—It was ARDC which got the ball rolling on this latter, very important area of research, in January, 1958.

ARDC moved fast on this project and in less than a year two contractors—The Martin Company and Lockheed Aircraft Corporation—were air-launching test vehicles. Under ARDC supervision, some 23 companies were studying designs and launching techniques.

Most of the companies are now preparing detailed proposals which are to be submitted to ARDC this spring. On the basis of these proposals, the Air Force will decide how or whether to proceed with the ALBM idea. It is a safe bet that at least one contract will be awarded.

- **Computer brain**—Sam Anderson has shown rare ability to keep track of the vast ARDC organization in what his aides call his "computer brain." He retains nearly all he reads or hears and frequently astounds his co-workers by citing minute details of one of the multitudinous projects under his supervision. His natty appearance reflects the tidy mind, down to the precise white-blond mustache.

The measure of any top executive is how his underlings feel about him and in that respect Sam Anderson rates tops. To a man, his ARDC staff regrets his departure while rejoicing in his promotion. Although a firm commander, he is always pleasant, they say, and shows a great deal of consideration for the lowliest people under his command.

His interest in people was pointed up during his Korean tour, when he encountered a young Korean pianist named Tong "Tony" Han. Anderson, a music lover, was impressed by the youngster's talent, and along with two other USAF officers, he sponsored Tony's entry into the United States and a course at the famed Juilliard School of Music. The young Korean has since performed with several of America's top symphonies.

ARDC's Far-flung Set-up and How It Works

The sprawling command which Anderson will turn over to his still-unnamed successor now numbers 45,600 personnel, about half military and half civilian. About one-quarter of these people are in the technical, engineering or scientific brackets.

ARDC's job is largely research management. Within the last year, it has awarded 3600 contracts to 1100 industrial organizations and an additional 1600 contracts to 249 universities and private research groups. Its contractual obligations run to about $700 million a year, and its overall obligations—including operations, facilities and equipment—amount to $2.8 billion.

It is a multi-faceted command whose range of responsibilities runs from modification of weapons and equipment which have been in service for years to handling the USAF participation in military and civilian space research projects. It administers basic and applied research and operational development in the broad fields of propulsion, materials, electronics, geophysics, biosciences and aeromechanics.

The command structure consists of headquarters at Andrews AFB, Md., near Washington, seven major centers covering various fields of interest, and two sub-centers.

The major centers include:

- **Wright Air Development Center,** at Wright-Patterson AFB, Dayton, Ohio, which conducts basic and applied research in several areas with an extensive "in-house" research program, augmented by contractual work.
- **Air Force Cambridge Research Center,** Bedford, Mass., which handles basic and applied research in electronics, geophysics and human engineering, both in-house and contractually.
- **Air Force Missile Development Center,** Holloman AFB, N.M., which is interested in scientific fields relating to short-range missiles, guidance subsystems and biodynamics testing.
- **Arnold Engineering Development Center,** Tullahoma, Tenn. (see p. 31, this issue of m/r), which covers aerodynamics and simulated altitude propulsion testing.
- **Air Proving Ground Center,** Eglin AFB, Fla. which researches in fields related to system engineering and operational evaluation testing, and non-nuclear weapons.
- **Air Force Special Weapons Center,** Kirtland AFB, N.M., which works closely with the Atomic Energy Commission on nuclear weapons applications, effects and testing.
- **Rome Air Development Center,** Griffiss AFB, N.Y., which handles research in intelligence devices, ground-based electronic devices for surveillance and flight control, and electromagnetic radiation warfare.

In addition to the centers, there is the Air Force Office of Scientific Research in Washington, D.C. AFOSR conducts the exploratory research program of ARDC through contracts with the scientific community. It manages about three-fifths of ARDC's contractual basic research.

ARDC has a similar unit in Brussels, the EOARDC, or European Office, ARDC, which draws upon the available scientific talent in free Europe and provides a means of communication between U.S. and pro-Western scientists in Europe.

Brisk and businesslike in speech and manner, Anderson is impatient with wandering presentations. Staff members have learned to "give him the facts" in brief, concise fashion.

- **For relaxation**—Anderson is not all business, however. He is an avid fisherman and hunter, and he likes an occasional card game. On plane trips, instead of poring over papers or calling a staff meeting, he prefers to organize a bridge game in the belief that relaxation better prepares him for upcoming business.

Anderson also tries his hand at golf, but not too successfully of late, possibly because of his hectic duties.

- **Old ties**—Sam Anderson goes to Air Materiel Command as no stranger, because of the close ties between his old and his new commands. Weapon systems project offices are jointly staffed by ARDC and AMC personnel. Schriever's ballistic missile division works hand in hand with an AMC counterpart office, as does the air defense systems integration division at Bedford, Mass. ARDC and AMC have a number of other overlapping interests, and Anderson himself got together at least once a month with Rawlings for a formal joint staff meeting.

- **Some opinions**—Anderson has some opinions of interest to industry. For one thing, he shares the belief that manned aircraft will figure in defense for quite a while.

"There will be a reduction in inventory of manned aircraft," he says, "but they still have potential—and I'm speaking of atmospheric aircraft." As to whether manned aircraft development can be carried beyond the B-70, Anderson is inclined to think it can.

"When I came here less than two years ago, the general opinion was that you could not build an intercontinental bomber to fly supersonic all the way. In that short time it has been demonstrated that you can. The big problem is heat transfer, but with the progress being made in that direction, we can't rule out anything. We need both aircraft and missiles in complement, because it is easier for the enemy to defend against either one than it is to defend against both."

On where the U.S. stands vis-a-vis the Soviet Union in research and development, Anderson thinks the Soviets are "about as advanced as we are, in some areas ahead, in some behind."

"But," he adds, "you have to qualify your judgment on what they want to do."

He concedes the Soviets the edge in missile propulsion, but adds "we have the power for as far as we want to go." There is evidence that the U.S. is more advanced in materials research, he states.

Pioneer Deviates in Trajectory

But first stage *Jupiter* fired perfectly with less than one second lift-off delay by ABMA team

by Paul Means

WASHINGTON—Early Tuesday morning, March 3, a group of sleepy NASA and Army space experts announced that the United States had finally done what the Soviet Union had done two months before—only not as well.

Pioneer IV, moving into its orbit as a captive asteroid of the sun, had deviated below its expected trajectory, thereby moving past the moon at too great a distance to carry out a major part of its planned experiments.

After two nights of delays, the countdown of the U.S.'s fifth lunar attempt proceeded smoothly. The launch team had to use all of its built-in delays in order to fire the vehicle at exactly 12:10 a.m. According to AMOC Commander Gen. John B. Medaris, the team missed by less than one second.

The Army's big *Jupiter* booster fired perfectly. The deviation in trajectory was thought to have occurred in the performance of one of the later stages.

Thrust and velocity, shortcomings of previous lunar probes, was more than adequate. The four-stage *Pioneer IV* achieved an initial velocity of 24,890 statute miles per hour,—95 mph less than planned, but 210 mph more than was needed to escape the earth's gravitational pull.

Tracking stations around the world reported picking up the 960.05 megacycle signals of *Pioneer IV's* 90 hour duration battery-powered radio transmitter minutes after launch. The strength of the signal itself was important to NASA scientists, since *Pioneer III's* signal had been weaker than expected, which could have been the result of some as-yet-unexplained condition in space.

Two Geiger-Mueller tubes in the 13.50 pound 20 by 9 inch payload measured radiation as the vehicle went through the Van Allen belts. One tube was shielded with lead to give specific information about high energy radiation.

The tubes are expected to return information about clouds of radiation between the belts and the moon, and about the radiation streams of the sun.

Because *Pioneer IV* missed the moon by 35,000 miles rather than the planned 15,000 to 20,000 miles, a camera triggering device to be used on future probes was not set off by a photo-electric sensor, which would have been activated by the moon's light.

Little to no information was received about the moon's gravitational field, or about its magnetic field and the radiation within it because of the wide miss.

In comparison, the Soviet Union's *Lunik* moved to within 5,000 miles of the moon, which means that if the vehicle's instruments were working properly, Soviet scientists know a great deal about the moon and its properties that U.S. scientists have yet to learn.

On its way toward a solar orbit, *Pioneer IV* was hardly affected by the moon's gravitational field. It's perihelion will be slightly inside the earth's own orbit, and its apohelion will be slightly outside. *Pioneer IV* will complete each orbit around the sun in about the same amount of time as the earth's year.

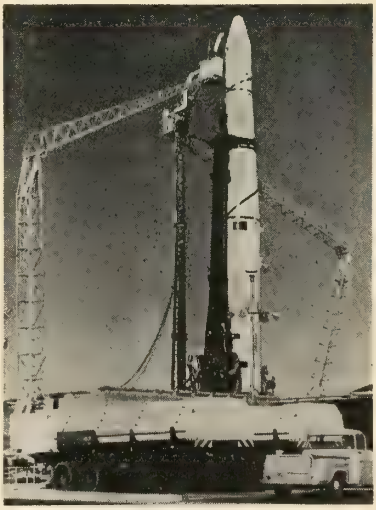
One question left unanswered by *Pioneer IV's* successful launch was the reason for the delay of three months since the failure of *Pioneer III*. ABMA officials claim that the vehicle could have been launched two months ago, and that they were prevented from doing so by administrative delay.

Discoverer I Orbit Dubious

Intermittent signals may be caused by satellite's tumbling or solar heat reviving cold batteries

WASHINGTON—As m/r went to press, DOD would not say definitely that *Discoverer I* launched Feb. 28 from Vandenberg AFB was in orbit. Intermittent radio signals had given credence to the belief that it was in a polar orbit and was operating on its 15 channels.

One theory was that the batteries were dead because of the extreme cold and perhaps would come to life when heated sufficiently by the sun. The telemetry package has two battery power systems—one of short duration to furnish power for the initial tracking and telemetry operations, and a secondary system for general telemetry designed to last several weeks.



A second theory regarding the intermittent transmissions was that the vehicle was tumbling end over end as it circled the earth at 18,000 mph, thereby causing the erratic signals. This could mean that one of the most important pieces of the new equipment was not working—an infrared horizon scanner which sends signals to the guidance system to provide attitude stabilization.

The first stage modified *Thor* had a burning time of 157 seconds.

The second stage Lockheed vehicle was powered by a Bell Hustler engine using white fuming nitric acid and JP-4, with a "slug" of UDMH for hypergolic ignition. Its height is 18.8 feet with a diameter of five feet. It weighed 7,000 pounds, and after exhausting the fuel, had an orbital weight of about 1,300 pounds including the 40-pound payload.

The major purpose of the first launch was to test ground and launch equipment and telemeter certain measurements including atmospheric densities.

The attitude stabilizer which may not have worked incorporates a three-axis control system after the orbital boost and during the short coast period between the burnout of the first stage and the firing of the second stage.

The planned orbit was on a magnetic heading of 183°. It was apparent from fragmentary data available that the perigee could be as close to earth as 146 miles and the apogee as far as 550 miles.

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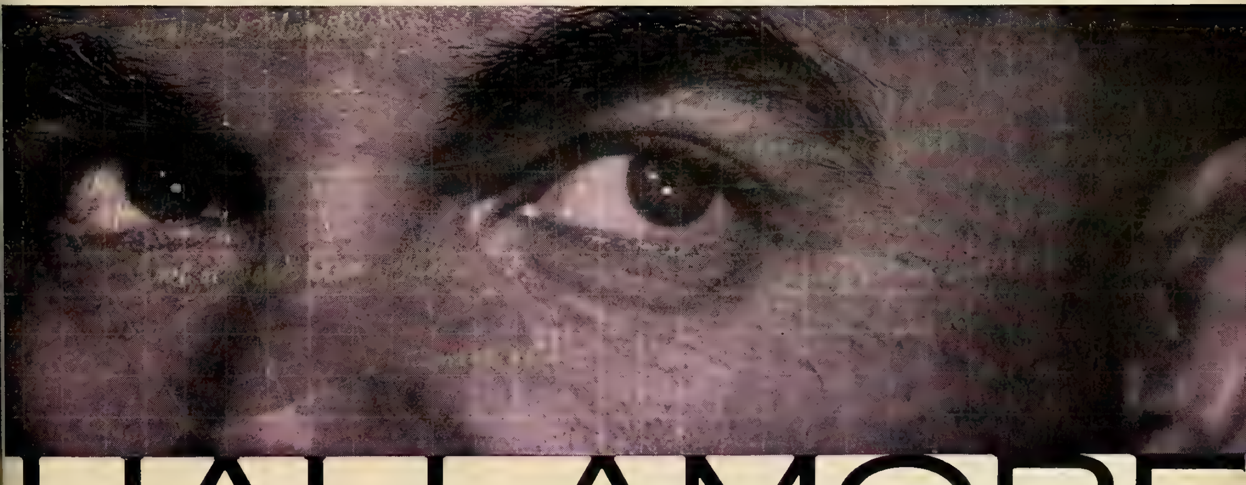

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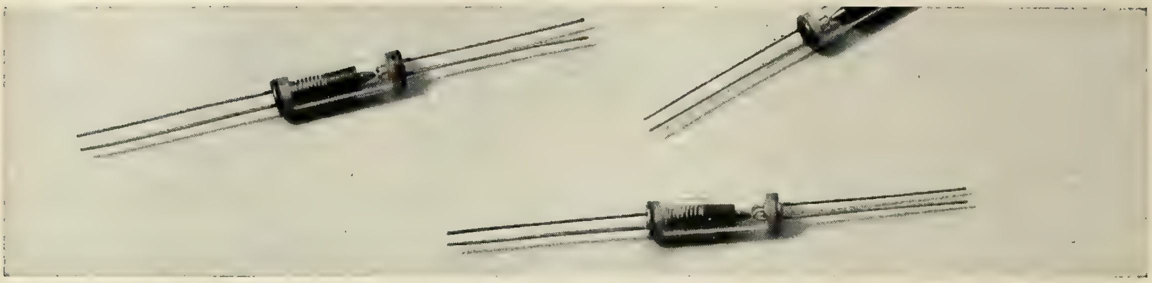

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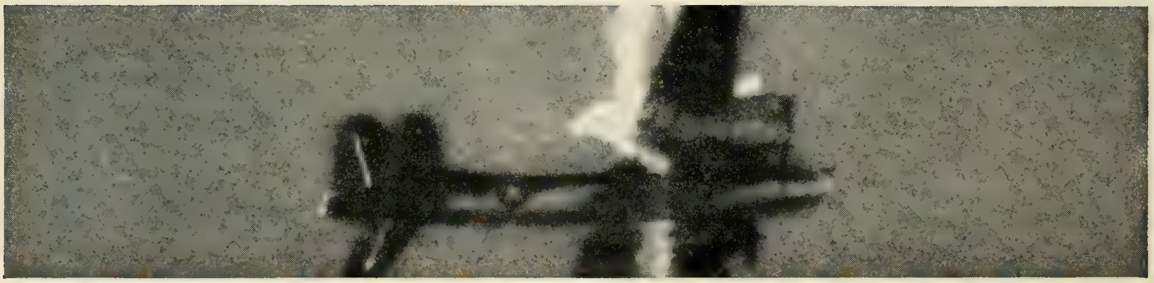

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For additional information please write: Hughes Products, Marketing Department, International Airport Station, Los Angeles 45, California.

SPECIFICATIONS

MECHANICAL—Body Size: Maximum diameter 0.252"; length .920". Total weight: Less than 0.1 oz.

ELECTRICAL—**Before Firing:** Insulation resistance is greater than 200 megohms. Minimum breakdown voltage 600 volts.

Firing: 2 volts minimum required. Actual voltage dependent upon closing time desired.

After Firing: Circuit resistance less than 0.3 ohm.

ALTITUDE—Any.

OPERATING TEMPERATURE: –55°C to +125°C.

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PHIL FERRIS watches the burning of a new liquid monopropellant inside a high-pressure bomb with Lucite viewing windows.

Wyandotte Pressing Research Work on Monopropellants

Company has new plant producing EtO and may be turning out other organic oxides, but much work is classified.

WYANDOTTE, MICH.—The field of monopropellant molecules is coming in for increased emphasis at Wyandotte Chemicals Corp., a leader in this research field since 1949. High on the priority list is new applications for aminoethycellulose perchlorates (AECP) as composites and in double base solids as a high energy additive.

Beyond ethylene oxide, the company is reluctant to talk about its propellants. However, William Cuddy, who heads up Wyandotte's liquid propellant research, recently presented a classified paper at a monopropellant symposium in Detroit, sponsored by ARS.

Wyandotte is a producer of ethylene oxide and recently put on stream a $37 million Et0 plant at Geismar, La. Other organic oxides—notably propylene oxide—are also growing production items that may figure into the monopropellant picture for Wyandotte. Just how much Et0 is being used in missiles is unknown.

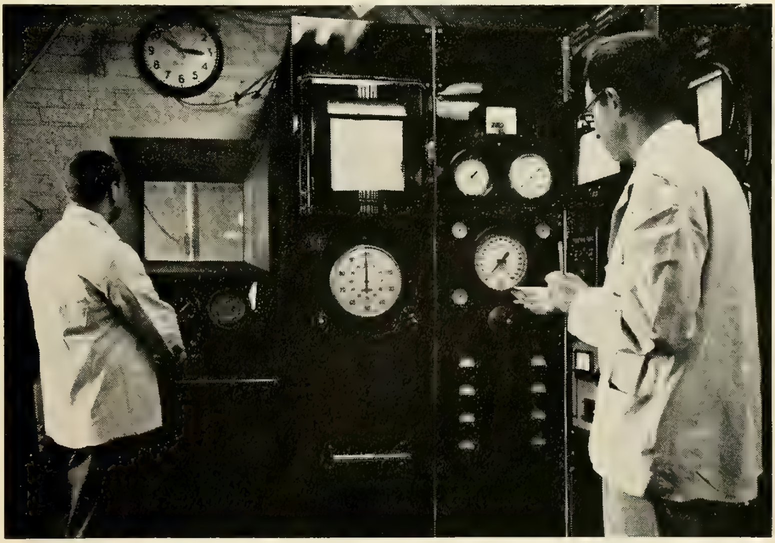
Auxiliary power units in some big ballistic missiles use the low-impulse, low-reaction temperature oxide. Wyandotte's 60 million lb./yr. production of this material is small compared to other producers who are grinding out tonnage lots. Total U.S. production capacity of Et0 this year should be near 1.5 billion pounds.

Et0 use, in missiles at least, is small, and more money is to be made in selling systems than in a material that sells for under 20¢ per pound. Conservative estimates of the oxide use in missiles are on the order of 200 tons/year.

Grasp of this concept is pointed out by Sundstrand's progress in pushing Et0 for ballistic missiles APU's. Dr. Arthur Ash, a key in Sundstrand's Et0 APU efforts originally came from Wyandotte Chemicals after having worked at Wyandotte's High Pressure Lab.

So, Wyandotte is coming around to turning out complete systems rather than just trying to sell monopropellant chemicals. At best, Wyandotte's work on new monopropellants can be described as early. Under a Bureau of Aeronautics contract, lab work is going on to develop a monopropellant with an I_{sp} of over 250 seconds. Production, costs, stability, and sensitivity are some of the "engineering details" that remain to be ironed out. One of the most important is the matter of sensitivity, Wyandotte admits, and tendencies to detonate will have to be licked.

To permit concurrent hardware and propellants evaluation, four new test cells, two chemical labs, general services, and office space are being expanded. Therefore, the primary purpose of Wyandotte for now will be to develop both solid and liquid high energy rocket propellants for the services as well as related hardware. Several of the experimental propellants have already demonstrated higher performance than any currently used in U.S. missile programs.



LARGE CONTROL panels automatically start the firing of rocket motors. The panel also records the test results. Pat Howard and Bill Simpson watch the test. The company has built two modern chemical laboratories to expand high pressure work.

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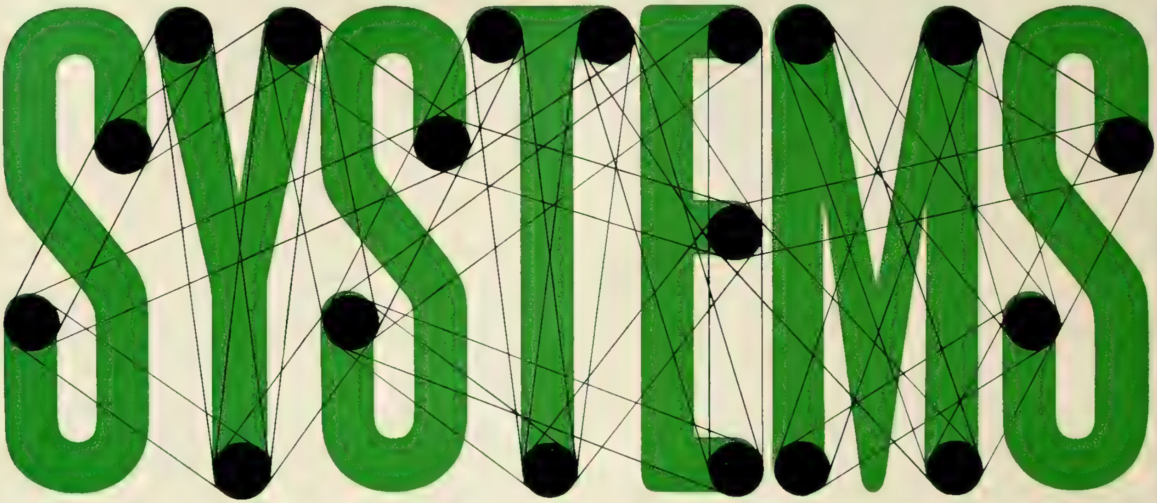

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COMPUTER ENGINEER to perform physical, mathematical analyses for solving complex control problems by use of digital computers. Applications in missile systems and special-purpose computer systems such as DDA plus extensive experience in computer analyses.

RADAR ENGINEER to analyze ultimate limits and present techniques and to develop new concepts providing topographical sensors for advanced airborne and space systems. Design airborne radar pulse, microwave and deflection circuitry. Analyze doppler radar systems to determine theoretical accuracy and performance limitations. Experience with transistor circuits or radar test equipment is highly desirable.

TRANSISTOR ENGINEER to design transistor amplifiers, delay lines, transistor-tube conversion circuits, and develop specifications for transistorized equipment.

ENGINEERING PHYSICIST to assist in design and development of advanced solid state computers. Must have extensive background in electronic fundamentals plus knowledge of solid state phenomena and mathematics. Must be capable of participating in logic development with minimum supervision.

For details, write, outlining background and interests, to: **Mr. R. E. Rodgers**
Dept. 604C2
IBM Corp.
590 Madison Avenue
New York 22, N. Y.

IBM

INTERNATIONAL BUSINESS MACHINES CORPORATION

letters

Teflon Troubles

To the Editor:

Re your special report on wire and cables. I have watched for some rebuttal to your excellent article on teflon-insulated wire that would substantiate the problems that we have encountered in using such wire on missile components and for missile wiring.

Evidence from missile component malfunctions and laboratory tests indicates that the teflon insulation on wire becomes a conductor of electricity when the teflon begins to vaporize. Mono tetra fluoro ethylene is liberated when the teflon vaporizes, and evidently the mono fluoro conducts the electricity. At 730°F teflon starts to vaporize, therefore, the temperature environment into which the teflon-insulated wire is placed must be scrutinized for possible high-temperature spots that could cause the wiring to short out during operations. Booster boat tail or booster engine compartments have exhibited high temperature in the order of 800 to 1000°F.

Considerable effort has been expended to reduce the temperature environment within engine compartments to below 500°F. Until the engine compartment temperatures can be positively controlled, the use of teflon-insulated wire in engine compartments would require shielding and cooling to assure that the wire is kept below the vaporization temperature of teflon.

A teflon-coated wire malfunction in a solenoid valve was brought to the attention of the writer. The teflon-coated wire wound solenoid had become over-heated due to a fluid stoppage in the valve. The solenoid coil shorted from the inner wiring through the coil to the outer wire of the coil. The fluorine gas flow could be traced from the inner wire through the coil by the crystalization of the vaporized teflon on the wire of the coil.

Typical test data show the flow of 10 amperes from a 5-volt supply between conductors of teflon-insulated cable 20 seconds after flame was applied to the table. The current flow ceased with a continual application of heat after the teflon is vaporized. Tests indicate that teflon begins to vaporize at about 730°F. Wire with teflon insulation if subjected to spot temperatures in excess of 730°F would have its insulation resistance reduced and would fault between conductors.

J. G. Lindberg
Senior Research Engineer
North American Aviation Inc.
Downey, Calif.

F-108, NUCLEAR TURBOJET, AND RAMJET PROJECTS OFFER CHALLENGING OPPORTUNITIES TO PROFESSIONAL ENGINEERS AND SCIENTISTS

Advanced projects for air and space operations now underway in the Controls and Accessories Division at Marquardt Aircraft offer engineers and scientists challenging opportunities in a variety of technical areas. Here, where we are dealing with development problems on high-performance systems with stringent design and reliability requirements, professional engineers will find real challenge and opportunity for accomplishment.

Project personnel are currently working in such areas as the engine control system for the G-E nuclear turbojet; inlet control systems for the McDonnell F-4H, North American F-108 and the North American Hound Dog missile; the fuel control system for the supersonic Bomarc's ramjet engine; auxiliary power systems, pumps, and actuators; and are developing a unique and advanced space power unit.

C & A Division activities range in scope from preliminary design through final production.

Professional engineers and scientists capable of making contributions in these and related areas are invited to investigate the employment opportunities at Marquardt. You will find a combination of significant, active projects and a lively interest in new ideas, creating an environment for professional growth. May I suggest you write Mr. Floyd Hargiss, Professional Personnel Department, 16552 Saticoy Street, Van Nuys, California?

Roy E. Marquardt, *President*

◄ C & A Division engineers made many contributions to the "state of the art" when they developed the fuel control system for the supersonic ramjet engine.

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MAGNETOHYDRODYNAMICS

EXPANDING THE FRONTIERS OF SPAC

MAGNETOHYDRODYNAMICS: Lockheed's 3rd Annual Symposium* on this important new field—which deals with the behavior of conducting fluids in magnetic fields—attracted physicists from all over the world. As portrayed by the artist, man's earliest experiments with magnetic forces involved the use of the ancient lodestone. Solar prominences are a dramatic example of such forces under investigation today.

ECHNOLOGY

Lockheed Missiles and Space Division has complete capabilities in more than 40 areas of science and technology—from concept to operation. Headquarters are at Sunnyvale, California, on the San Francisco Peninsula, with research and development facilities located in the Stanford Industrial Park in nearby Palo Alto and at Van Nuys in the San Fernando Valley of Los Angeles. A 4,000 acre, company-owned test base, 40 miles from Sunnyvale, conducts all phases of static field testing. In addition, complete flight testing is conducted at Cape Canaveral, Fla., Alamogordo, N.M., and Vandenberg AFB, Calif. as an integral part of every stage of missile and space programs at Lockheed.

The Division's advanced research and development programs now under intensive study provide a fascinating challenge to creative engineering. These programs include: man in space; space communications; electronics; ionic, nuclear and solar propulsion; magnetohydrodynamics; oceanography; computer research and development; operations research and analysis; human engineering; electromagnetic wave propagation and radiation; materials and processes and others.

Lockheed's programs reach far into the future and deal with unknown environments. It is a rewarding future which scientists and engineers of outstanding talent and inquiring mind are invited to share. Write: Research and Development Staff, Dept. C-29, 962 W. El Camino Real, Sunnyvale, California.

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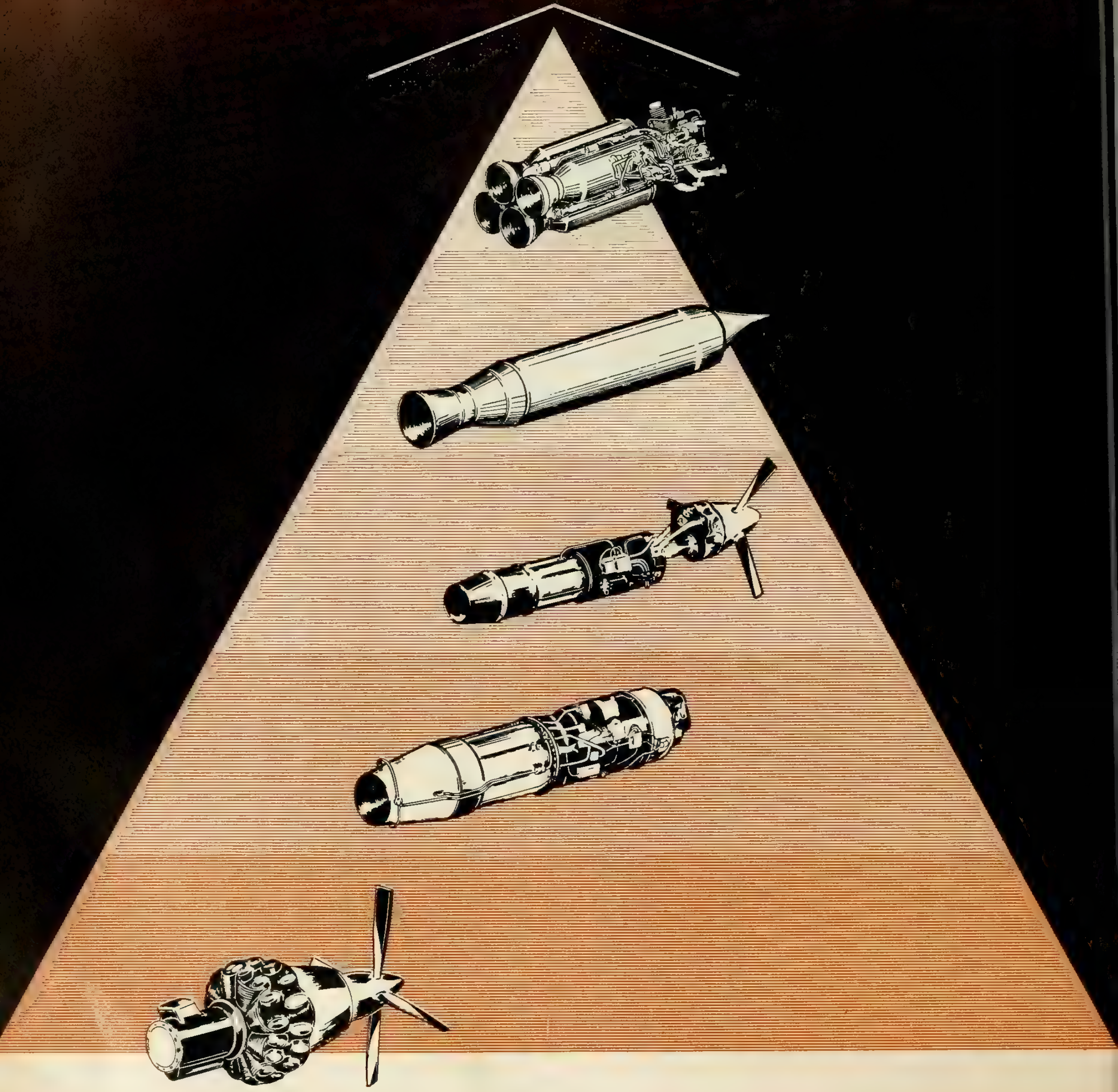
*Copies of the proceedings of the first two symposiums were published by the Stanford University Press, Palo Alto, Calif. and are available in book form. Results of this year's symposium will be published shortly by the same house.

CONTROLS

FOR THE FULL SPECTRUM OF PROPULSION SYSTEMS



Bendix* has long been a leader in supplying controls and fuel systems for all types of aircraft engines. Today, Bendix is proving to be a natural for new challenges in related missile fields—on ram jets, rockets, nuclear power, and other advanced propulsion systems. So, when it comes to controls, remember that Bendix has the background—and is anxious to share it in solving your problems. *REG. U.S. PAT. OFF.

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Cover Story:

Weapons Testing Booms at AF's Arnold Center

Facility supports nearly all top-priority systems of services as well as lunar probes. Wind tunnel used in achieving escape velocity for first time anywhere.

TULLAHOMA, TENN.—The Arnold Engineering Development Center has more than 20 test units booked solid for as much as 14 months to come in its efforts to keep the Air Force abreast of the space age.

A rising percentage of the continuing program of design modifications and changes is devoted to guided missiles and space vehicles rather than ramjets and manned aircraft.

Maj. Gen. Troup Miller, Jr., commanding officer, says the 10-year-old Air Research and Development Command facility really has come into its own during the last 18 months—with the dawn of the space age.

• **Tunnel breakthrough**—One of the most significant tests here was recorded in February, when a velocity of approximately nine miles a second was generated in the arc-driven hypervelocity tunnel Hotshot 2 of the Gas Dynamics Facility. This was the first time escape velocity had been reached, or exceeded, in a wind tunnel.

This facility, along with two others, is supporting almost all of the top-priority Army, Navy and Air Force missile weapon system projects, including *Atlas, Polaris, Minuteman, Dyna-Soar, Bomarc, Thor, Jupiter* and *Sergeant*. Tests are scheduled for *Titan*. And the *X-15* and B-70 bomber programs have been tested here.

One company official recently said missile tests run at Arnold achieved results which could not otherwise have been accomplished without setting up additional facilities at an estimated cost of $25 million. The Center, incidently, was designed by Sverdrup & Parcel, Inc., consulting engineers.

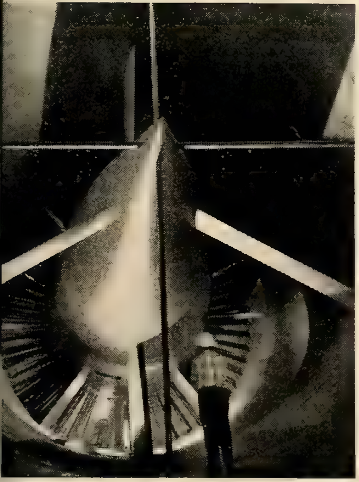
• **Transonic circuit**—The Transonic circuit is a continuous-flow closed circuit tunnel capable of operating pressure levels from a near vacuum to stagnation pressure of 2.5 atmospheres. It can test large-scale aerodynamic models and full-scale air-breathing and rocket propulsion systems. Recent modifications will permit solid and liquid rocket propellant tests. Both the Transonic model tunnel and the supersonic model tunnel are being used in rocket testing.

The Hotshot 2 arc-driven tunnel is so involved in boost-glide and re-entry projects that tunnel research (for which it was originally designed) can be accomplished only on a second-priority basis. Air in this 50-inch diameter tunnel, initially confined to an arc chamber by a diaphragm near the throat of an attached convergent-divergent nozzle, is heated and compressed by an electric arc discharge and expanded by the conical nozzle to the test section and vacuum tank. A useful run of about 20 milliseconds duration is obtained.

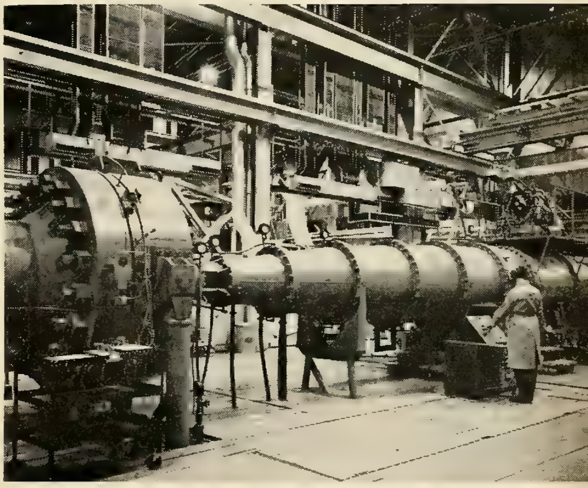
• **Test cells**—Velocities from 100 to 2500 mph, altitudes to more than 100,000 feet, and airflow temperatures from –120° to plus 650°F can be simulated in the facility's test cells. A full-scale solid propellant rocket has been test fired at a simulated altitude of 90,000 feet. Results of high-altitude solid burning studies in the Engine Test Facility have prompted design changes in several missiles and space vehicles.

Extensive testing in support of the lunar probes includes work with spin rockets, third-stage rockets, verniers and retrorockets.

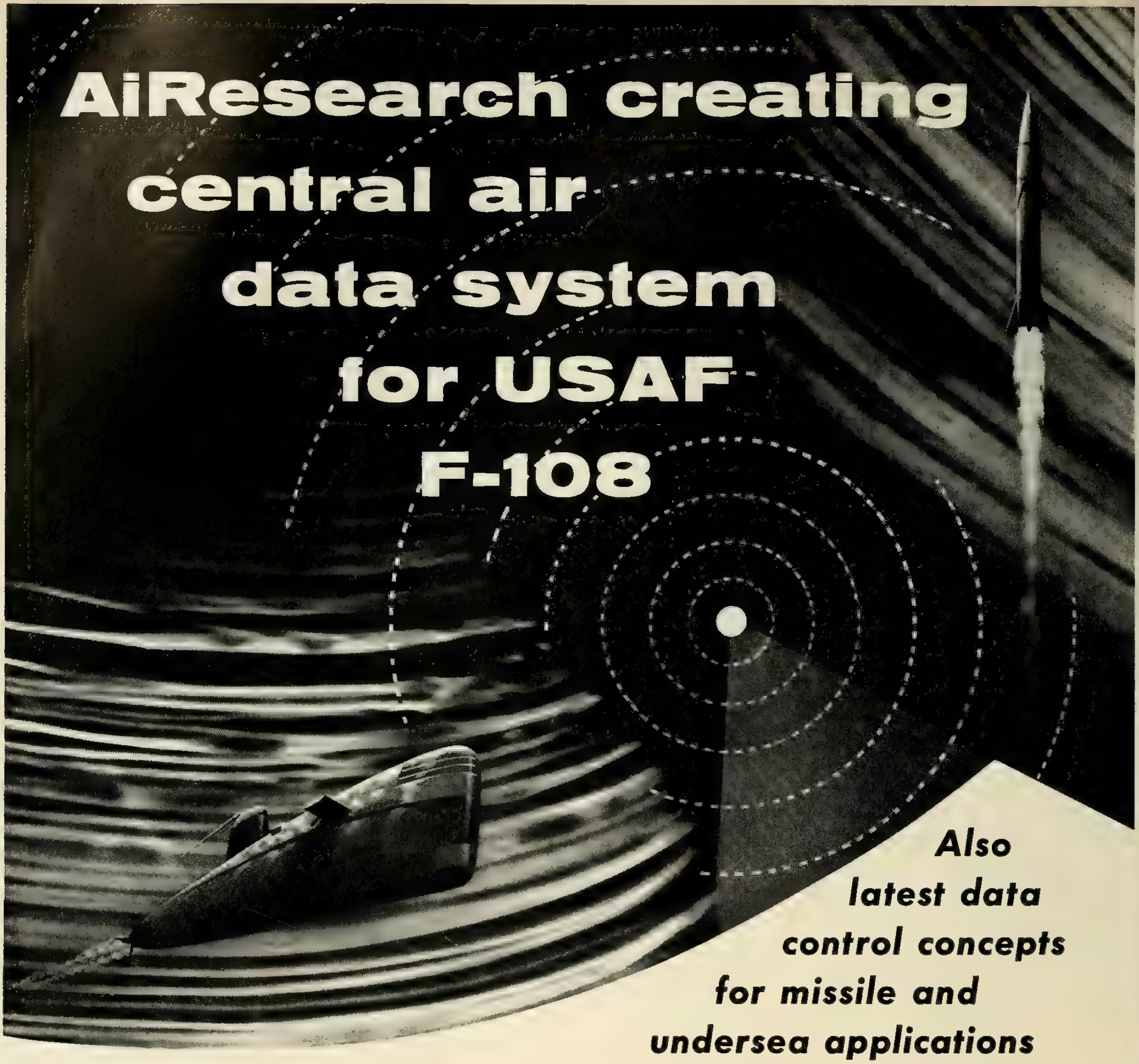
The 16-foot test section of the Propulsion Wind Tunnel's Transonic circuit has made possible full-scale aerodynamic testing, showing the value of work with production models of missiles. Current testing of rockets broadens use of this wind tunnel—one of the most versatile in the free world.



VARIABLE STATOR vanes in transonic circuit of the propulsion wind tunnel help control the airflow from three-stage compressor at Arnold.



TUNNEL B2 of Gas Dynamics Facility, with 50-inch diameter, is only large continuous-flow wind tunnel in nation to operate at Mach 8.



AiResearch creating central air data system for USAF F-108

Also latest data control concepts for missile and undersea applications

The AiResearch Centralized Air Data Computing System will sense, measure and automatically correct for air parameters affecting flight of the North American-Air Force F-108 Interceptor and will supply simplified air data to the pilot. Eliminating duplication of components, the system will cut down space and weight requirements over decentralized systems by many times.

The centralized combination of transducers, computers and indicators represents an integrated system concept combining electrical, electronic, pneumatic, hydraulic, electro-mechanical and mechanical servo capabilities. Technical experience in each of these fields enables AiResearch to achieve optimized systems covering a wide range of functions while meeting the most rigid specifications. Systems management is an integral part of each Central Air Data program enabling AiResearch to assume the overall responsibility for systems or subsystems.

The first fully optimized central air data system is already operational aboard the Navy's supersonic F4H-1, the first aircraft to fly with such a system. Similar equipment is on the Navy's first weapon system, the A3J "Vigilante." This broad AiResearch systems capability is now being applied in the fields of military aircraft, commercial jet transports, missiles and submarines.

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New Robot Is Big Step in Numerical Control

Automatically Programmed Tool developed at MIT translates jargon and guides cutting.

by James J. Haggerty, Jr.
Contributing Editor to m/r

CAMBRIDGE, MASS.—The latest wrinkle in automatic machine tooling is a master robot which can understand human language and translate it into cutting directions for a numerically-controlled machine.

This new system, regarded as a very important step in adjusting manufacturing techniques to the complex requirements of the space age, offers a method of reducing further the time between initial design of an aircraft or missile part and its actual production. It could cut costs by reducing man-hours and machining time, and it permits automatic and highly accurate machining of more complicated parts.

Demonstrated to a press and industry group at Massachusetts Institute of Technology last week, the system is known as APT, for Automatically Programmed Tool. It represents a major advancement in numerical control—the method of guiding a machine tool without a human operator by the "player piano" technique, in this case a punched tape which directs the cutting movements of the machine in turning out a part.

Numerical control has made gradual inroads in aircraft and missile manufacturing processes over the last few years and today there are 80 such automatic machines operating in the industry.

• **Shorthand jargon**—The breakthrough provided by APT lies in the method of producing the tape. Where formerly the tape data for a given part was laboriously calculated mathematically by humans, the APT computer gets its instructions in a simple, easy-to-prepare jargon. For example:

"ON KUL, ON SPN, GO RGT, TL LFT, CIRCLE/CTR AT, +2, +3, RADIUS, +5."

This language, fed to the electronic brain on punched cards, translates into:

"Turn on the coolant, turn on the spindle, go right with the tool on the left side along the circle whose center is located at x equals 2, y equals 3, with a radius of 5."

An extra in the APT computer system is its capability of preserving the design integrity of the part by checking up on the accuracy of the information fed it. Ben S. Lee, assistant public relations director of Aircraft Industries Association, provided an unscheduled demonstration of APT's double-check talent during a press inspection of the system.

Asked to design his own part specifications and feed it to the machine, Lee drew up some hastily-compiled data for a modern curvy ash-tray.

The APT computer digested his information in seconds and came back with a terse teletype reply:

"GEOMETRICALLY IMPOSSIBL."

Red-faced Lee took some consolation from the brainy computer's report. "At least I can spell 'impossible'," he said.

• **Language course**—This would mean nothing to an ordinary electronic computer. However, the APT system's designers worked up a simple "training course" to teach the language to general purpose computers already in wide industry use. The text book in this training course is a deck of 12,000 to 18,000 punch cards, worked up by MIT and its collaborators over a two-year research period which involved computer thinking equivalent to 25 man-years.

Insertion of these cards into a general purpose computer converts it to an APT computer which can understand the language and guide a number of machine tools through the proper motions to produce a part automatically and with greater accuracy than heretofore.

Development of the language is credited to Dr. Douglas T. Ross, an MIT mathematician. His computer jargon consists of 107 words of six letters or fewer, adequate to handle a wide variety of machining jobs, including manufacture of highly complex parts.

• **How it's applied**—The part-manufacturing sequence with APT is this:

A designer conceives the part, detailed drawings of it are made, and these drawings are converted into APT language, a job considerably more simple than manual programing and one which can be handled by any technician after a short training period. The language statements are then punched on "part program cards"—another simple job—fed into the computer and the rest of the operation is automatic.

The APT system has two added advantages: first, the computer language was designed so that a standard procedure can be followed throughout the aircraft and missile industry; second, the system was purposely designed to allow future growth to accommodate still more complex parts.

APT was developed under a cooperative program spearheaded by MIT's Servomechanisms Laboratory. The project was funded primarily by the Air Force's Air Materiel Command, with help from 19 member companies of Aircraft Industries Association, who are using their own money for service testing and continuing development of the system.

• **Hailed by military**—Lt. Gen. Clarence S. ("Bill") Irvine, Air Force Deputy Chief of Staff/Materiel, hailed APT as a significant advance. He pointed out that, in the technological war with the USSR, the military must not only pioneer advanced types of equipment, but it must make an equal effort to advance design and production techniques.

Developments in the manufacturing processes such as APT make contributions in two very important areas: cost-cutting in a period when weapons systems complexity dictates higher and higher prices, and reduction of lead time.

An example of the advantages of APT in these areas was cited: the programming task for a typical wing rib

(Continued on page 47)

Missile Needs Pose Challenges for Ceramics

Industry expects demand within decade for materials that will take temperatures up to 4000°F in missiles.

by R. T. Inglis and D. L. Krout, Jr.

Senior Design Engineer and Design Specialist, respectively, at Convair/Pomona, Division of General Dynamics Corporation.

POMONA, CALIF.—The high speeds of today's missiles and the resulting high temperature environment are merely scratching the surface of the so-called "Thermal Barrier."

Ira H. Abbott, Assistant Director of Research for Aerodynamics and Flight Mechanics for the National Aeronautics and Space Administration, has informed the Aircraft Industries Association that top operating temperatures within the next five years are likely to be 2000°F for prolonged exposure, and 3000°F for a few minutes.

Within ten years, Abbott wrote AIA, operating temperature of 2500°F should be expected for an hour, and 4000°F for a few minutes.

- **Anticipated needs**—The NASA official said that within five years low-density thermal insulation for structural and electrical materials probably will have to stand up to temperatures as high as 2500°F—and that this range is likely to go up to 3000°F within ten years. Ceramic insulation, he said, will be needed to meet temperatures from 1500° to 4000°F.

"It is believed," Abbott added, "that there will be a need for protective coatings for metallic and non-metallic materials that will be capable of withstanding temperatures to 3000°F, and that flame plating and ceramics . . . to withstand oxidation and erosion at temperature as high as 5000°F will be needed."

High-temperature structures are the problem of the missile and aircraft industry, and a challenge to the ceramics industry. This article will examine this area in more detail.

Manufacturing Requirements

Because aircraft and missile manufacturers hesitate to rely on a single supplier, the production process should not be so proprietary as to preclude multiple sources.

Naturally, the process must be completely reliable, insuring an end product of uniform quality. There should be quality control methods for the non-destructive detection of hidden flaws. And production facilities and labor market must be adequate to meet delivery dates.

The manufacturing tolerances generally used on missile structure are as follows:

Diametrical = Down to ± .010 in./ft. of diameter
Length = Generally ± .030″ per assembly
Thickness = 10% on thin gauges and progressively less on thicker gauges

Fig. 1 illustrates the tolerance range used on stainless steel sheet. These tolerances are necessary to insure not only fit and contour, but also the weight control and strength so essential to missile manufacturing. Center of gravity shift and weight variation seriously affect performance.

Radomes, a more exacting field, can require contour tolerances of ± .002 inch and thickness control of 0.8%.

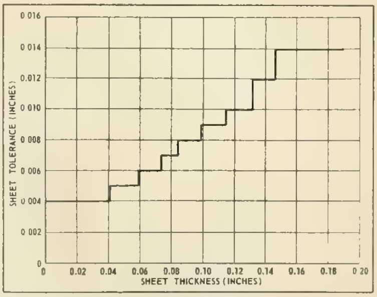


FIG. 1 indicates the tolerance range used on stainless steel sheet.

- **Handling problems**—Undoubtedly, ceramic structures will bring handling problems somewhat different from those previously experienced by the missile industry and armed services. These will include handling not only within the factory but also in transit, in storage and in the field with the military services. The experience and recommendations of the ceramic industry will be invaluable here.

Industry cooperation will be required to acquaint missile designers with engineering techniques, terminology, and special manufacturing problems unique to ceramics.

Strength Properties

Figs. 2, 3 and 4 compare the strength to weight, stiffness to weight and thermal shock resistance of three metals and two ceramics.

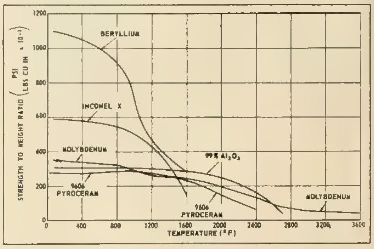


FIG. 2—The strength to weight ratio, comparing metals to ceramics.

These are molybdenum, Inconel X, beryllium, alumina and Pyroceram (9606).

Fig. 2 demonstrates that while beryllium and Inconel X are excellent below 1200°F on an ultimate tensile strength to weight basis, they fall off rapidly above this and only molybdenum compares favorably with the two ceramics thereafter. It should be noted that compression allowable stresses of ceramics are many times greater than their tension allowables.

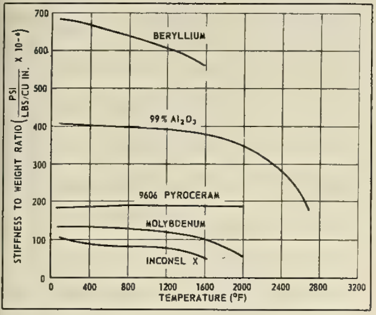


FIG. 3—The stiffness to weight ratio of metals vs. ceramics.

Fig. 3 shows that the trend of the two ceramics will be superior to the metals in the higher temperature range for a stiffness, Young's modulus, to weight ratio comparison. Beryllium will fall off rapidly after 1600°F. It should be noted that structural stiffness is important in missiles to insure advantageous control response rate.

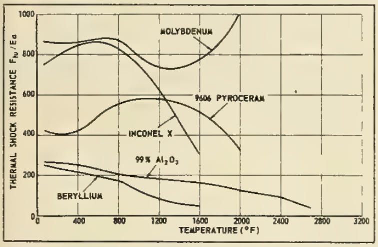


FIG. 4—Comparison of thermal shock resistance factor with steady-state temperature differentials.

Fig. 4 compares these materials for an elastic range thermal shock resistance under conditions of steady-state temperature differentials. Steady-state temperature differentials are defined as conditions where temperature variation is linear through the specimen. In all fairness, it should be pointed out that all of the metals will be far superior in the plastic range due to their greatly reduced tangent moduli and ductility.

Designing for Ceramics

Ceramics used extensively as materials in airframe primary structures must be subjected to stresses close to their ultimate strength.

To accomplish this, the aircraft designer must take into account all stresses and stress concentrations regardless of how small an area they may act upon. The smallest local failure will result in a complete and massive failure, because of ceramic's complete lack of ductility. This type of analysis is much more time-consuming and therefore more costly than that required for metal structures.

- **Some allowables**—Before one can efficiently design a ceramic structure, he must have design allowables. The following are major factors affecting the allowable of a given ceramic body:

1. Surface conditions: Tests show a spread of 4 to 1 between the best results and those from specimens with severe stress concentrations resulting from surface finish. The R.M.S. finish in ceramics is not the criterion for stress concentration. The bottom radius of minute surface finishing scratches determine the stress concentration effect.
2. Size effect: Generally the larger the body the lower the allowable.
3. Method of manufacture: Is it slip-cast, pressed, etc?

Thermal Stresses

Temperature gradients through the wall of a structure will, in general, induce tensile stresses on the cooler side and compressive stresses on the hotter side. This is a particularly acute problem in high-speed aircraft and missiles where thermal fluxes are of such great magnitude.

Fig. 5 illustrates the effect of steady-state thermal gradients on the thermal stress across the walls of two unrestrained ceramic cylinders made of Corning Glass Pyroceram (9606) and high purity alumina (Al_2O_3).

The outer diameter was assumed at 2000°F with a straight line decreasing temperature towards the inner diameter. A notch sensitivity factor of 2.0 was arbitrarily assumed for both materials, that is, 50% of test allowables.

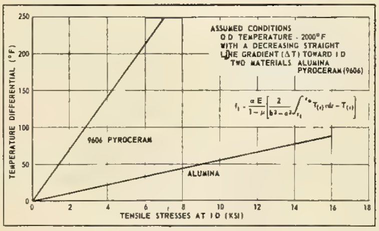


FIG. 5—Effect of temperature gradient on cylinder wall thermal stresses.

Although Pyroceram would fail at 7000 psi, as compared to alumina at 16,000 psi, the Pyroceram could withstand a considerably higher temperature gradient before failure than the alumina. This is due to the fact that the thermal expansion, Poisson's ratio and Young's modulus of Pyroceram are considerably lower than that of alumina.

It should be pointed out that these thermal stresses do not include combination with any stresses due to external loads (aerodynamic and inertia loads). Thus, thermal gradients, and the attendant thermal stresses induced, materially reduce the external load carrying capacity of the structure.

Reinforced and Pre-stressed Ceramics

At first blush, it would appear that reinforced and pre-stressed ceramics will solve the problem of the relatively low tensile allowables of ceramics as compared to metals. This is probably stimulated by reference to reinforced and pre-stressed concrete. The following discussion will demonstrate some of the problems involved in accomplishing a pre-stress on high-strength and high-temperature ceramics subjected to tensile stresses.

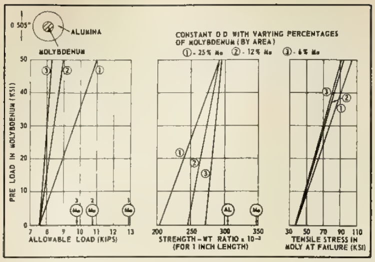
The relative stress distribution in a composite structure is proportional to Young's Modulus of Elasticity of the materials. Using alumina as the ceramic, it becomes apparent that the metallic reinforcing should have a large E (Young's Modulus of Elasticity).

This will tend towards having the low-tensile-strength alumina and the high-strength reinforcing fail simultaneously under external loading. Also, the metallic reinforcing material should maintain strength through the temperature range of the ceramic. These two pre-requisites make molybdenum a logical choice.

The firing temperature of alumina is above 3100°F. If the metallic reinforcing were pre-loaded in the ceramic at the firing temperature, the pre-load would be destroyed due to both the ceramic firing shrinkage and the thermal contraction during the cooling of the alumina as compared to the molybdenum. Thus, the pre-loading must be accomplished while the alumina is relatively cool.

- **Pre-loading effects**—The reinforcing will have to be pre-loaded on the finished ceramic body either in pre-drilled holes or in an external configuration. Fig. 6 demonstrates the effect of pre-load in the molybdenum and the ratio of alumina to molybdenum, by area, on the tensile load capacity of a given composite specimen at room temperature.

Fig. 6a demonstrates that the greater the percentage of molybdenum, the greater the load-carrying ability with pre-load. However, it should be noted that there is no difference in load-carrying capacity when there is no pre-load. This is due to the fact that there is practically an equal E (Young's modulus) and thus an even stress dis-



FIGS. 6a, b & c—Effects on alumina tensile specimen due to variations in molybdenum reinforcing and pre-stressing at room temperature.

tribution between the alumina and molybdenum.

Notice the encircled symbols along the abscissa, which demonstrate the load-carrying capacity of a pure molybdenum tensile specimen of a weight equivalent to the corresponding numbered composite specimen. In each case, the pure molybdenum specimen was capable of carrying a greater load than its equal weight composite counterpart.

Fig. 6b replots Fig. 6a on a strength to weight basis. With a zero pre-load the specimen with the least molybdenum reinforcing is superior. All three specimens seem equal with 50,000 psi pre-load. The encircled A_L and M_o on the abscissa indicate the relative strength to weight ratio figures for pure alumina and molybdenum. Again these are superior to the composite specimens.

- **Composite drawbacks**—Fig. 6c shows the stresses in the molybdenum at failure of the alumina in the composite specimen as affected by variations in pre-load. It should be noted that these become quite large and any further increase in the pre-load would yield the reinforcing, and, thus, gain little in load-carrying ability.

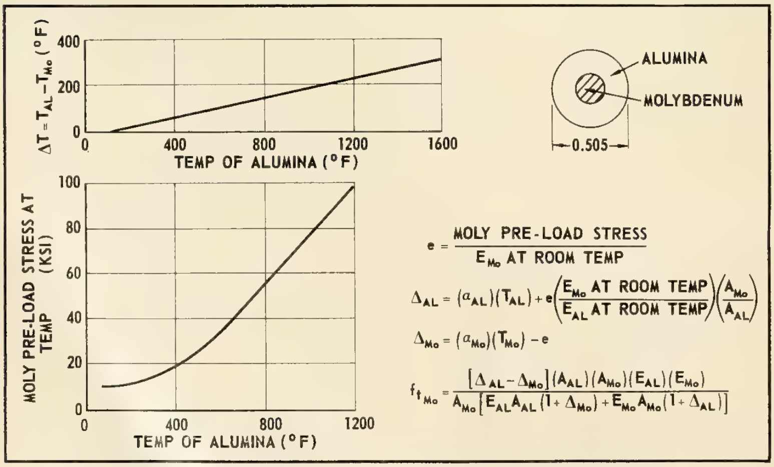
Granted that this composite specimen is of two specific materials, it does point out, however, that reinforcing and pre-loading will actually lose ground when compared to the basic materials alone on a strength-weight basis.

It is of interest to note that the tensile allowable used on the alumina was 38,000 psi which is extremely optimistic. A design allowable would have to be substantially lower to account for the notch sensitivity of the material. This would only tend to emphasize the facts already presented.

If a lower modulus, but high-strength ceramic were used, the net result would be to put a greater portion of the load in the molybdenum. The latter would fail rather than the ceramic if the ceramic modulus was low enough. Still, it does not appear that this would increase the allowable load appreciably over that of the pure ceramic; certainly not enough to justify the added complexity and expense of using reinforcing and preloading. This, of course, applies only to tensile stress regions.

- **Composite reaction**—The preceding discussion dealt with the room-temperature effects of reinforcing and pre-stressing. Possibly of greater interest is the reaction of a pre-stressed composite tensile specimen to temperature.

A composite tensile specimen of alumina with molybdenum is ideal due to the closely matched coefficients of thermal expansion of the two materials. By using specimen #2 of Fig. 6 with an initial 10,000 psi pre-load in the molybdenum, Fig. 7 demonstrates the effect of increased temperature and gradient on the molybdenum pre-load.



$$e = \frac{\text{MOLY PRE-LOAD STRESS}}{E_{Mo} \text{ AT ROOM TEMP}}$$

$$\Delta_{AL} = (\alpha_{AL})(T_{AL}) + e\left(\frac{E_{Mo} \text{ AT ROOM TEMP}}{E_{AL} \text{ AT ROOM TEMP}}\right)\left(\frac{A_{Mo}}{A_{AL}}\right)$$

$$\Delta_{Mo} = (\alpha_{Mo})(T_{Mo}) - e$$

$$f_{t_{Mo}} = \frac{[\Delta_{AL} - \Delta_{Mo}](A_{AL})(A_{Mo})(E_{AL})(E_{Mo})}{A_{Mo}[E_{AL}A_{AL}(1+\Delta_{Mo}) + E_{Mo}A_{Mo}(1+\Delta_{AL})]}$$

FIGS. 7a & b—The temperature effect on pre-load for alumina specimen. (12% molybdenum reinforcing at 10,000 psi pre-load.) (Ref. Fig. 6, specimen 2).

Fig. 7a shows a hypothetical, but reasonable, temperature differential between the alumina and molybdenum. Fig. 7b demonstrates the effect of temperature increase and temperature differential on the pre-load stress in the molybdenum. Young's modulus of elasticity at the various temperatures was used. Therefore, only the elastic range of the molybdenum is shown. Note the extremely high pre-load stress when the alumina temperature is 1200°F and the molybdenum is lower by 230°F.

Of course, the higher the pre-load, the lower the external load will be before failing the reinforcing. The pre-load curve will tend to flatten out in the plastic range of the molybdenum. Thus, with permanent set in the molybdenum, a recycling of temperature, or any cooling of the specimen, will radically reduce the pre-load effect.

In fact, if the recycling carried the specimen back to room temperature the "reinforcing" could then be reversed into a compression stress. Thus, the reinforcing would then be a detriment to the specimen. Creep in the reinforcing will also reduce the pre-load effect.

Structural Attachments

If ceramics are to be used as a primary structural material for missile airframes, satisfactory ceramic-to-ceramic and ceramic-to-metal attachments must be developed. Some required features are:

1. Strength: The attachment must withstand the structural loads over wide temperature ranges and high heating rates. Under these conditions, the thermal stresses resulting from differential expansion and gradient will add to the structural loads.

2. Stiffness: High fineness ratio missiles (high length to dia. ratio) require high over-all stiffness. This in part determines the natural frequency of the structure—the stiffer the structure, the higher the frequency. A high frequency structure has two major advantages: fewer problems from flutter and faster response, which enables the missile to maneuver faster.

3. Weight: Weight must be held to a minimum for obvious reasons.

4. Size: A thin cross section is most desirable. All attachments for cylindrical body sections restrict access to the internal volume of the airframe.

5. Assembly: Extensive time, extreme care, special techniques and tools required for field assembly should be held to a minimum.

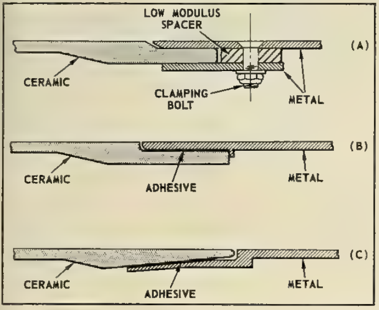
6. Cost: Fabrication cost must be held to a reasonable figure.

7. Materials: Strategic materials

should be incorporated in the attachment only as a last resort.

Approaches to the Attachment Problem

• **Clamped attachments**—This method (shown in Fig. 9a) is almost universal with the glass and ceramic industries. It consists of clamping the ceramic on all edges with massive metal frames, putting the ceramic in compression. All ceramic-to-metal load transfer is by friction. The frame is stiff enough so that little load is transferred into the ceramic.



FIGS. 9a, b & c—Proposed clamped and cemented attachments for ceramics in missiles.

If this ceramic-metal combination is to be exposed to wide temperature variations, a metal must be selected that has a thermal coefficient of expansion which closely matches that of the ceramic over the operating temperature range.

This attachment has some disadvantages. The weight involved is more than can be tolerated in an efficient airframe design. Metal must be placed on the outside of the structure, thereby limiting the attachment to a temperature that the metal will withstand. As the metal is on the outside, it will be exposed to the heat source more than the ceramic.

Consequently it will heat faster, resulting in a greater thermal expansion, even if the coefficients are identical. This differential expansion will reduce the clamping force and in turn reduce the attachment's load-carrying capacity.

• **Cemented attachments**—(Figs. 9b and 9c) This type of attachment can be lighter in weight than the clamped attachment, for the cement will force the metal and ceramic to work as a unit, up to the limit of the cement. In this type of attachment, the load is transferred from ceramic to metal through the cement, primarily by shear.

For temperatures below approximately 500°F, organic cements can be used. These have the ability to yield, reducing the load induced from differential expansion.

For higher temperatures, an inorganic cement must be used. Generally these will withstand much higher temperatures but they lack ductility. Therefore, we now must match the expansion coefficients and heating rates of the ceramic, metal and cement.

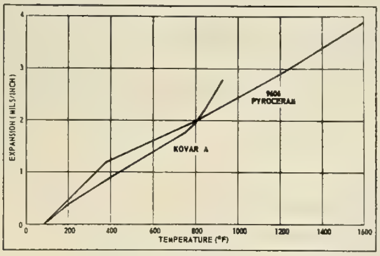


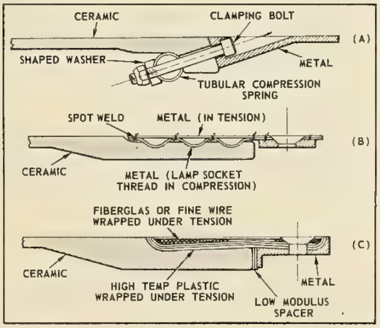
FIG. 8—Linear expansion vs. temperature for Kovar A and 9606 Pyroceram.

Fig. 8 is a plot of two materials whose expansions match quite well between room temperature and 900°F. These are Kovar A and 9606 Pyroceram. An example problem in differential expansion will best serve to show the importance of an accurate match.

Assume concentric thin wall cylinders of equal spring constants having Kovar A on the outside with an average temperature of 900°F and Pyroceram on the inside at an average temperature of 700°F. A differential expansion of approximately .001 in/in. of diameter will be the result.

The attachment, however, forces the two rings to expand equally, introducing a tensile stress of approximately 8000 psi in the ceramic. This stress must be added to the stresses resulting from the thermal gradient in the ceramic and the external loads.

• **Elastically clamped**—(Fig. 10) In this type of attachment the non-ceramic portion can be metal or plastic, inside or outside of the ceramic structure.


CERAMIC
CLAMPING BOLT
(A)
SHAPED WASHER
METAL
TUBULAR COMPRESSION SPRING
SPOT WELD
METAL (IN TENSION)
(B)
CERAMIC
METAL (LAMP SOCKET THREAD IN COMPRESSION)
FIBERGLAS OR FINE WIRE WRAPPED UNDER TENSION
(C)
CERAMIC
HIGH TEMP PLASTIC WRAPPED UNDER TENSION
METAL
LOW MODULUS SPACER

FIGS. 10a, b & c—Suggested elastic attachment using metal or plastic.

Elastic deformation in the metal or plastic is intended to compensate for the differential thermal expansion between the two materials. The necessity of matching thermal expansions is therefore not as important in these approaches. These schemes appear to offer the best chance of working at temperatures above 1000°F.

In the scheme illustrated by Fig. 10a, a tension bolt has its head in the metal portion, and shank passing through an oversize hole or slot in the ceramic body, compression tube and washer, into a nut. When the bolt is tightened the tube tends to flatten, thereby clamping the ceramic and metal structures together.

When the composite structure is heated, this tube spring will deform more or tend to return to its original shape, depending upon the differential expansion. Thus a pre-load is retained over a wide range of temperature and gradient. The clamping force is limited by the elastic load range of the tube.

In Fig. 10b the threaded metal portion is installed on the ceramic. The outside metal sheet then is wrapped over the threads with a high hoop tenload, and welded to the thread prior to relaxing the hoop tension. This tension in the outside sheet will flatten the top of the threads, forcing the root into the groove in the ceramic.

Differential expansion between ceramic and metal will produce greater or reduced bending in the metal thread. This insures thread contact and acts as a pre-load.

Fig. 10c shows fiberglas and plastic tape wrapped and cured on the ceramic under tension. This is followed by wrapping individual filaments of fiberglas or fine wire under tension. A cover of fiberglas is placed on the outside for insulation. Elastic strain in the fiberglas and wire will insure a clamping force over a wide temperature range.

Protective Coatings

There is also a large field for ceramics as coatings to protect and insulate high-temperature metallic alloys. Such metals as molybdenum exhibit excellent mechanical properties at high temperatures but are also subject to severe oxidation at these temperatures in a normal atmosphere. Thus, ceramic protective coatings are desirable to provide longer metal life.

These coatings should inhibit oxidation, intergranular corrosion, and de-carburization; have low porosity; have good impact strength to resist spalling and chipping; provide good insulation, and possess good adhesion to the parent metal, plus an ability to withstand elongation of parent metal without fracture.

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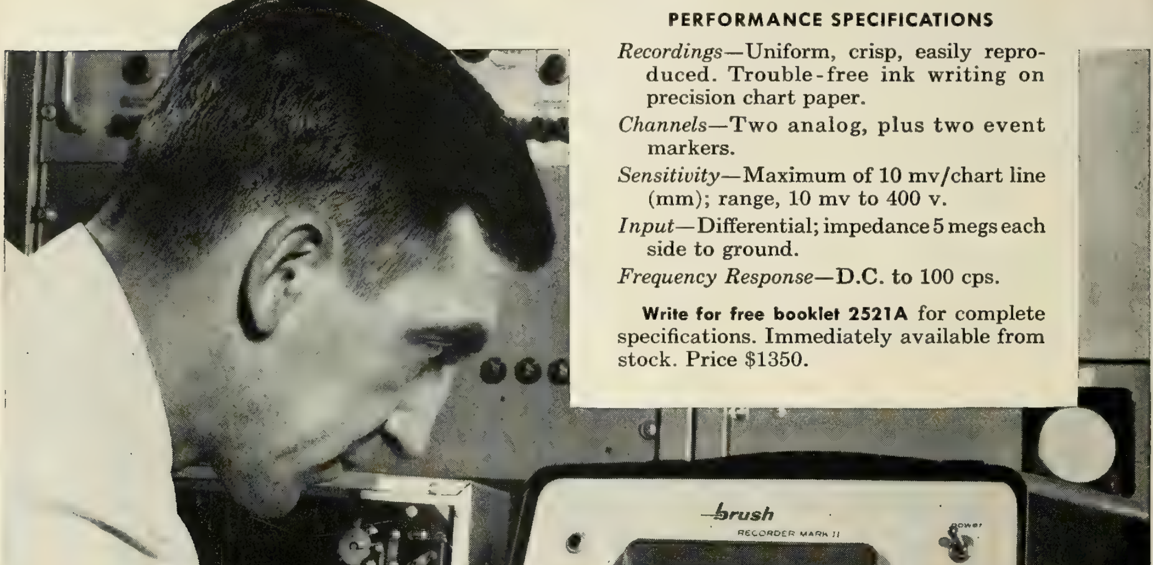

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Procurement Overhaul Sought

Saltonstall bill, aimed at cutting lead time and Pentagon red tape, has strong support in industry and among some high DOD officials.

by Erica M. Karr

WASHINGTON—If the Saltonstall procurement bill is enacted essentially as is, the defense industry may expect faster Pentagon decisions, and more responsibility without supervision.

Sen. Leverett Saltonstall (R-Mass.), ranking Republican of the Armed Services Committee, pointed out when he introduced the measure recently that "obsolete procurement practices" are red-taping both industry and Defense officials at a time when "the capability for lightning-fast response is essential for our nation's security." His bill is aimed at reducing both lead time in new military weapon development, and unnecessary Pentagon administrative practices.

• **Broad backing**—Saltonstall claims his proposal is supported by almost every major industrial association, members of the Harvard Business School defense procurement group, and ranking military procurement officials—"although the Defense Department has not committed itself formally."

However, some Pentagon officials would like a little more "flexibility" than the weapon systems concept currently provides and may get stubborn about the limitations which Saltonstall's bill would impose in this area.

The Aircraft Industries Association indicated it would support "the basic objectives" of the measure, which will undergo a detailed analysis by an AIA legislative committee.

In brief, the bill is designed to boost small business participation in subcontracting; put negotiation, competitive negotiation and formal advertising "on an equal par"; encourage use of incentive and fixed-price contracts; extend the weapon system concept, and permit simpler specifications, preferably of the performance type.

The Massachusetts Senator said the original spur for the bill was the testimony of a Harvard Business School professor during the post-*Sputnik* investigation of our space program. Dr. J. Sterling Livingston pointed out at the time that Soviet lead time on weapons development was about half ours—an average of five years compared to the "10 to 11 years to develop and produce an air-weapons system," in the United States.

The bill is a refinement of a similar measure introduced by Saltonstall late in the last session. "A great deal more effort has been devoted to the bill during the recess of Congress," Saltonstall said, and it now represents "the best judgment of many of the most experienced men in the procurement field."

• **Congressional sanction**—Under the Armed Services Procurement Act of 1947 the purchase rule is for advertised bidding with 17 exceptions under which the Defense Department can negotiate its contracts. These include contracts which involve classified data, perishable items, research work or standardization, and those which call for speedy action, one particular brand, small quantities or professional services. Still another exception is contracts involving only one source. In actual practice during the past few years, over 85% of the military's funds were spent under this form of "exception" contracting. Involved is a complex determination process to justify a "no advertised bid" decision.

Although the exceptions require no competition, the Pentagon has been using "competitive negotiation" with two or more firms whenever feasible. The Saltonstall bill encourages use of the competitive approach by calling for either advertised bids or competitive negotiation whenever this is "consistent with the needs of the military departments."

Unqualified negotiation would continue under the exception provision "when no competition is possible or when overriding considerations . . . preclude competition."

The proposal to elevate negotiated procurement to the same legal level as advertised bidding is expected to meet strong opposition from some legislators who feel there has been too much negotiation and not enough advertised bidding. The House Armed Services Committee's Investigations Subcommittee, headed by Rep. F. Edward Hebert (D-La.), plans a fine-tooth-combing of this subject.

• **Weapon systems legalized**—Although the Air Force and—to a lesser extent—the Navy have been using the weapon system concept, this has been an administrative determination. The Saltonstall bill would give it legal sanction and extend its use under the term "operational system" to cover facilities and equipment which are not weapons.

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It would require the head of each military department to name a manager for each operational system. He would have authority and responsibility from start to finish—through the planning, budgeting, research, design, development and delivery of the system and its logistic support.

Saltonstall feels there is now too much scattering of authority. There is no one office to which a contractor can go for a quick decision, and much time is wasted going through channels. The operational system manager's office would have authority to come up with answers as they are needed. The bill would also leave more of the decision-making to industry itself.

Although the weapon systems have cut lead time considerably, there are certain obvious risks in centralizing such authority in one company: Prime contractors obviously do not like to farm work out if they can figure out a way to keep it in their own shop. This tends to narrow the industrial base for military procurement and could slow down a project if the contractor has to make plant changes to produce a new item.

Saltonstall's bill calls for the prime contractor to subcontract "the maximum practicable amount" competitively and to see that small business gets a fair shake.

Although the bill would not require that this be written into prime contracts, the intent of the bill is clear. And Defense procurement officials know from experience that powerful microscopes are used by the tireless investigators on Capitol Hill.

- **Specious specs**—Specification-happy procurement officials have cost the nation inestimably in time and money, both for the Pentagon and industry. Detailed requirements for one electronic tube, for example, cover 190 pages. One West Coast manufacturer, who complained that the product would not work if he followed the specifications laid down under his contract, was told by the Pentagon to go ahead anyway. After the contract was completed, it was suggested, he could apply for another cost-plus contract to make an item that would work.

The new bill calls for the "simplest" specifications possible, expressed "in terms of performance rather than in terms of design and manufacturing details" whenever practicable.

- **Renegotiation eased**—The legislation would seek to amend the Renegotiation Act to exempt fixed-price advertised-bid and incentive contracts from renegotiation. "To subject any such contract to renegotiation, as is done by present law, subjects the contractor to speculative, potentially inequitable, costly and time-consuming second-guessing," Saltonstall said. "Any necessary price redetermination should be negotiated between the contractor and the procuring agency after all costs under a contract have been ascertained. The services have the necessary authority to do this."

Under the current law, Saltonstall said, a manufacturer who has paid for renegotiation procedure and possible appeal to the tax court, may find he is in worse financial shape than if he had not affected any saving on the contract in the first place.

Although Saltonstall feels strongly about this part of his bill, renegotiation changes would involve the Senate Finance Committee and this provision of the bill may require a separate measure.

Cost contracts and cost-plus-fixed-fee contracts would be specifically authorized for research and development work under the Saltonstall legislation. At present, their use is barred if another type of contract is likely to be less costly.

- **Good prospects**—Although the bill will have its foes, chances for passage appear favorable. The first hurdle will be the Senate Armed Services Committee, which is waiting for the Pentagon's views before scheduling hearings.

Because of its technical nature, the Saltonstall measure has been termed "a long, hard, dirty but important job." Said one Capitol Hill observer: "It will all depend on whether the committee is willing to put up with the torture."

IT&T to Study Terminal Guidance for Air Force

Fort Wayne, Ind.—A contract to study space vehicle terminal guidance methods has been awarded to International Telephone and Telegraph Corp. by the Air Force's Air Research and Development Command.

The IT&T Astrionics Laboratory here will perform the study. This group, responsible for space technology research and development, is a branch of the Missile and Space Systems Laboratory, with headquarters at Nutley, N.J.

The program will cover the complex problems of guiding a space vehicle from the mid-course phase of its flight to the terminal point, including initial condition accuracies, adverse physical phenomena, required vehicle performance, environment, sensor characteristics and reliability.

Instrumenting the guidance system will involve sensing the ship's velocity vector relative to the space objects, altitude of ship above the surface, attitude of ship with respect to velocity vector, and latitude and longitude.

KEARFOTT TACHOMETERS

...compact, light-weight, high-performance

Kearfott offers one of the broadest lines of precision tachometers in the industry. Light, compact and resistant to temperature, vibration and shock, they are available for a wide variety of applications.

Size 11 (R860)

Integrating Tachometers, special types of rate generators, are almost invariably provided integrally coupled to a motor. They feature tachometer generators of high output-to-null ratio and are temperature stabilized or compensated for highest accuracy integration, rate computation, etc. In addition to reducing the in-phase null level toward zero, errors due to temperature effects are minimized over a wide ambient range. Linearity, in some cases as low as .01%, is usually better than ±.1%, while phase shift is 0±1°. For extreme accuracy, models with low temperature coefficient drag cups are also available.

Rate Generators feature high output-to-null ratios and are designed for application as rate servos and to provide damping in very high gain systems. These Kearfott units offer high linearity, high output and low inertia and are often integrally coupled to a low inertia motor; in this design the in-phase null is virtually reduced to zero. Quadrature null is as low as .25% of the 1000 rpm outputs while harmonics seldom exceed .1% of the output at 1000 rpm.

Damping Tachometers have relatively low output-to-null ratios and are designed primarily for damping purposes. They feature extremely low inertia and power consumption, linearity which is normally within ±.5%, and phase shift within 10° of reference. Kearfott damping tachometers are usually integrally coupled to a low inertia motor.

INTEGRATOR TACHOMETERS

(Typical Characteristics)

	Size 11 (R860)	Size 15 (T816)	Size 18 (V892)
Excitation Voltage (400 cps)	115	115	115
Volts at 0 rpm (RMS)	.020	.020	.010
Volts at 1000 rpm (RMS)	2.75	2.7	2.00
Phase shift at 3600 rpm	0°	0°	0°
Linearity at 0-3600 rpm	.07	.05	.07
Operating Temperature Range	−54° + 125°	−54° + 125°	−54° + 125°

RATE TACHOMETERS | DAMPING TACHOMETERS

(Typical Characteristics)

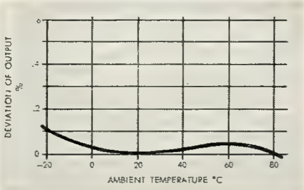
	Size 15 (R800)	Size 18 (V806)	Size 8 (M824)	Size 10 (P822)	Size 11 (R809)
Excitation Voltage (400 cps)	115	115	26	115	115
Volts at 0 rpm (RMS)	.013	.026	.015	.019	.019
Volts at 1000 rpm (RMS)	3.1	3.0	.234	.450	.5
Phase shift at 3600 rpm	5°	4.5°	10°	5°	5°
Linearity at 0-3600 rpm	.25	.25	.3	.3	.3
Operating Temperature Range	−54° + 100°	−54° + 125°	−54° + 125°	−54° + 125°	−54° + 125°

INTEGRAL SERVO MOTOR DATA

(Typical Characteristics)

	Size 8	Size 10	Size 11	Size 15	Size 18
No Load Speed (RPM)	5400	6600	5500	8000	8000
Stall Torque (oz. in.)	.3	.35	.55	.45	1.30
Excitation Voltage (400 cps)	18-40	26-40/20	115-40/20	115-40/20	115-115/57.5
Rotor Moment of Inertia (Gm.CM^2)	1.3	.76	7.7	7.0	35
Operating Temperature Range	−54° + 100°	−54° + 125°	−54° + 125°	−54° + 125°	−54° + 125°
Unit Weight (incl. tachometer)—oz.	3.1	4.6	9.0	14.0	30

TEMPERATURE



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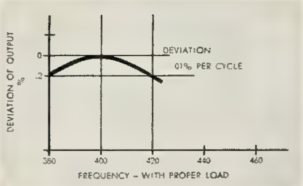

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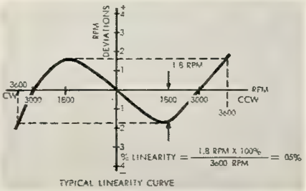

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RESISTOFLEX

missile people

The Radio Corporation of America has appointed **Maj. Gen. Francis L. Ankenbrandt,** USAF (Ret.) as deputy director of the USAF Communications Planning Project. The Air Force had disclosed earlier that the International Telephone and Telegraph Co., and RCA will develop and supervise the long-term program to determine present and future requirements of its network of wires and radio. Gen. Ankenbrandt, who is Manager, RCA Defense Projects, will serve under **Ellery W. Stone,** previously selected by I.T.&.T. to head the project.

FXR, Inc., has appointed **F. J. Gaffney** as executive vice president and general manager. He was formerly vice president for engineering of the Teleregister Corp.

AVCO has announced the appointments of **Louis R. Simov** as vice president-manufacturing, and **Dr. Leonard C. Maier, Jr.** as vice president-marketing (Defense Products) for the Crosley Division of the Corporation. Simov was formerly director of manufacturing for the Crosley Division, and Maier was formerly manager of the industrial and military tube operation of the Cathode Ray Department of the General Electric Co.

The Consolidated Diesel Electric Corporation has appointed **Albert Berger** as contracts administrator. A lawyer, Berger was formerly contract administrator for the Greenwich, Conn., laboratories of American Machine and Foundry.

Arthur J. R. Schneider has been promoted to chief engineer of the Technical Products Division of the Waste King Corp. He was formerly chief research engineer of the Division.

The Allen B. Du Mont Laboratories, Inc., has promoted **Charles A. Benenson** as assistant manager of its Systems Laboratory and **Michael V. Sullivan** as assistant manager of its Reconnaissance Laboratory. Both are new positions. The two men previously held the title of research engineer.

M. Clayton Burgy, assistant manager of Hercules Powder Company's explosives plant at Ishpeming, Mich., has been named technical specialist at the company's new rocket propellant plant at Bacchus, Utah. Succeeding Burgy will be **Clement J. Koeferl,** presently supervisor of Hercules' Carthage, Mo., plant.

North American Aviation's Los Angeles Division has announced the promotions of **Charles E. Ryker** to controller, **James E. Driskell** to director of personnel, and **Robert S. Johnson** to assistant to the general manager.

New Block Group Stresses Modular Concept

K-Block modules produced by ASCOP can be used in various telemetering systems as well as in data multicoding.

by Donald E. Perry

PRINCETON, N.J.—The Modular Concept in airborne data acquisition systems is getting another boost from Applied Science Corporation of Princeton (ASCOP), which is producing a new group of K-Block modules.

They have been engineered principally for multiplexing and coding (multicoding) data in pulse width PDM form, but can also be used in telemetering systems employing PCM, PAM and FM/FM techniques. K-Blocks are specifically designed to operate in the extreme environmental conditions of missiles and space vehicles.

This latest ASCOP production item brings added emphasis to the Modular Concept trend in military electronics where weight and size reduction, performance dependability, reduced maintenance and costs, and optimum flexibility for usage, are criteria.

Basically, the concept is the capability of assembling highly flexible electronic systems by using a variety of interchangeable "building blocks." But first, a standard must be established by which the physical proportions of all elements of airborne data acquisition systems are regulated.

Let's start with a rectangular solid as the basic modular shape. Any of its six surfaces could be used for attachment to adjacent modules. If the remaining dimension of each attaching module is made a multiple of one dimension (length, width, or thickness) of the basic module, then stacking is always possible between any side of an attaching module and a group made up of one or more basic modules.

Optimum flexibility of stacking is achieved when all the dimensions of the basic modules bear a multiple relationship to each other.

If this system is followed, the volume occupied by each module will be multiples of the volume of the basic module. By choosing a basic module of small volume, provision is made for almost unlimited volume flexibility, resulting in good component packaging density (components per cubic inch) for any size or type of circuit.

Criteria in module design for optimum flexibility calls for modular stacking from any of six surfaces; built-in standardized type input and output connectors which can serve as test point terminals; capability of independently performing with design environment; and for sales appearance, a distinctive appearance characterized by low silhouette functional outline.

This flexibility of assembling many functional systems in various physical arrangements—each fulfilling a specific requirement—allows the user to procure additional modules for maintenance replacement, or to add others for changes in flight test programs having different data acquisition requirements

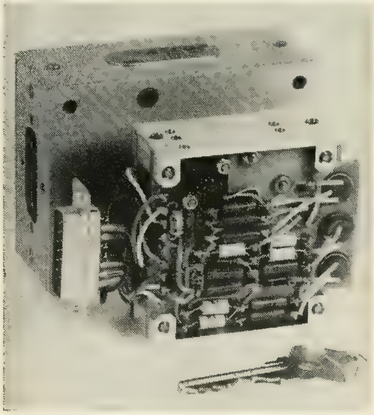
This has been the pattern for ASCOP in its K-Series line which can be systems-engineered into complete data acquisition units. Prestige item of the line is a multicoder with an electronic commutator as the principal module. It accepts 0-5V and –2½V imputs to plus 2½V imputs from a wide range of data pickups, multiplexing and coding them in pulse width form.

Low-level amplifiers raise millivolt inputs to the 0-5V level. Pulse width keyers code the output of the commutators.

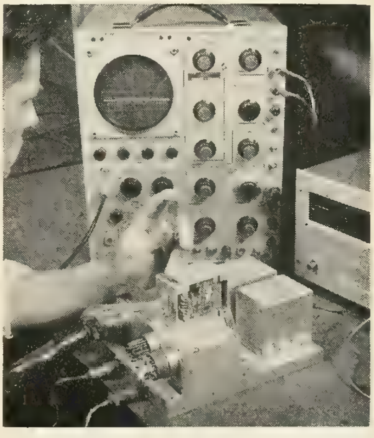
Some typical environmental specifications for the K-Series (which incidentally are backed up by a company-developed epoxy conformal coating for components protection against humidity, vibration and shock) are:

Temperature, –55C to 100C continuous; vibration, 30g at 5-2000 cps; shock, 200g for 11 milliseconds; constant acceleration, 200g for one minute along each direction of each major axis; altitude, 500,000 feet or better, and humidity, 95% R.H.

ASCOP K-SERIES Mixed Input Multicoder, assembled to fit missile test requirements. Dual commutator is on the left.

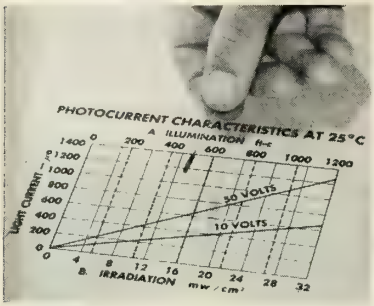


INTERIOR OF a K-Series transistorized Pulse Width keyer module, shown with outside casing, for coding the output.



A COMPLETE mixed-input (high and low level) multicoder shown on test bench. The engineer adjusts a modular keyer.

Photo-duo-diode Shuts Off current in Darkness



Dallas—A subminiature light-sensing photo-duo-diode which allows current flow when either junction is exposed to light, and shuts the current off in darkness, has been produced by Texas Instruments, Inc.

The company claims that the sensitivity of the new TI device is on the order of four times that of any other commercially available photosensitive unit.

The combination of sensitivity and subminiature makes the device suitable for applications such as the reading of data from punched tape and card systems. The single-ended glass case measures 0.500-inch by 0.085-inch in diameter. A minute glass lens is located at the end opposite the leads.

Designated the 1N2175, the new TI photo-duo-diode passes up to 1200 microamps when exposed to 1200 foot-candles of light. In darkness, the device will pass less than 0.5 microamps. Dissipation is rated at 250 milliwatts at 25°C and any biasing voltage up to 50 volts will operate the device.

As the 1N2175 is an N-P-N double-diode unit, it will operate on either alternating or direct current. It is derated to 125°C with a minimum operating temperature of –55°C.

ECS Opens Automatic Data Processing Center

Los Angeles—The Electronic Control Systems facility of General Dynamics Corporation's Stromberg-Carlson Division has opened its first automatic data processing center here.

The center will prepare magnetic tapes to the specifications of aircraft manufacturing companies on the West Coast who have installed ECS Digimatic Contouring Systems.

The finished tape will be a record of all the data and instructions necessary for cutting out a specified part on a given machine tool. All that the machine tool operator need do is to set up the raw material, place the magnetic tape on the numerical control console, and press a button.

Electronic Control Systems is manufacturing three additional tape preparation units which the Air Materiel Command will use to establish three additional Digimatic Tape Centers in the U.S. for support of Air Force contouring control systems.

Radio Sextant Can Track Sun, Moon Continuously

Cedar Rapids, Iowa—The Collins Radio Co. has constructed a radio sextant which, for the first time in history, can track the moon continuously.

At the company's Feather Ridge Observatory near Cedar Rapids, the sextant has been tracking the moon since late summer 1958.

The sextant has been delivered and installed aboard the Navy's experimental navigation ship, the USS Compass Island, where it will be used for navigational research.

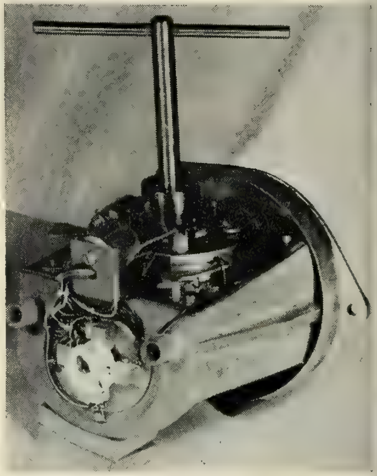
According to company spokesmen, the sextant is capable of tracking both the moon and sun under all weather conditions from moonrise to moonset and from sunrise to sunset.

The sextant, designated AN/SRN-4, was developed under a research and development contract with the Navy's Bureau of Ships with funding and technical supervision by the Special Projects Office, Bureau of Ordnance.

COLLINS AN/SRN-4 radio sextant.

The sextant utilizes a 5-foot parabolic type antenna, and a radio receiver built for the measurement of thermal radiation in the short microwave region. The receiver operates at a wave length of 1.8 centimeters and allows determination of antenna position.

Roll Reference Gyro Started by Spiral Spring



Los Angeles—A new roll reference gyro for missiles and drones developed by the Whittaker Gyro Division of the Telecomputing Corp., is energized by a spiral "clock" spring.

The spring-energized gyro reduces width and, once wound and armed at the factory, can be stored for indefinite periods without loss of accuracy.

The frame-mounted spring brings the rotor to operational velocity in less than 10 milliseconds after launching. The spring then disengages and permits the gyro to function as an inertial reference.

Weighing 35 pounds, the spring gyro is hermetically sealed, but is available in a tape dust-seal for proving tests. The control period for gyro operation is only 30 seconds, but others have been designed for up to 10 minutes of flight with minimum drift.

Low Noise Temperatures in Parametric Amplifier

Culver City, Calif.—Noise temperatures as low as 50° above absolute zero for a diode cooled by liquid nitrogen, and only 100° above absolute zero operating at room temperature have been obtained by Hughes Aircraft Co. in a high gain 3000-megacycle parametric amplifier using sample diodes of a newly developed type.

Hughes has begun producing these diodes at a rate of several hundred per week.

The diode is the heart of the parametric amplifier but also has other important microwave applications such as switching and harmonic generation. It

The man:

Pilot of a carrier-based Douglas A4D Skyhawk, this highly trained flier is on the alert for action at a moment's notice. Today, the Navy's water-borne "airfields" are an effective deterrent to the spread of brushfire wars.

The mission:

Providing support for our fast-moving military groups assigned to containment of Red threats. Here we see a phase of the brushfire operations at Quemoy.

The means:

The Douglas A4D Skyhawk, pocket-sized record-holding support aircraft:

Status	*In volume production*
Speed	*Classified*
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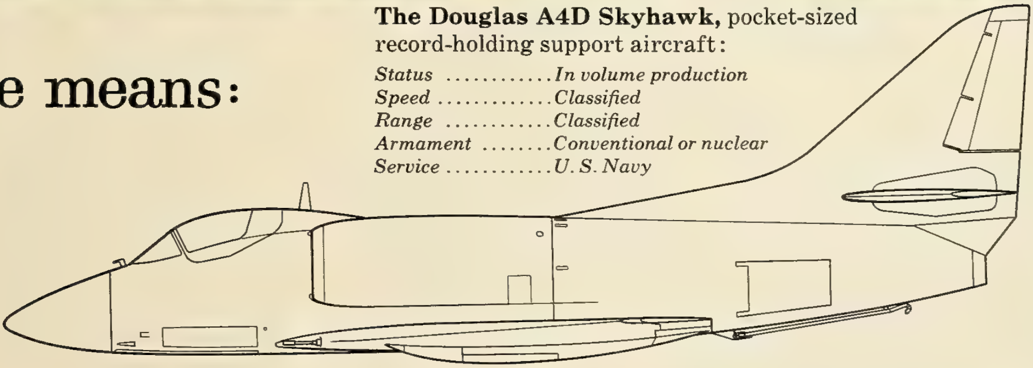
Armament	*Conventional or nuclear*
Service	*U. S. Navy*



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is available in two hermetically-sealed versions—one for the region below 1000 megacycles and a second for the microwave region. It reportedly costs about as much as good microwave mixer crystals.

• **Compared to masers**—The low noise performance of amplifiers using the new diode is expected to be in a range competitive in many applications with the solid state maser, which holds the record for absolute minimum noise performance. However, the parametric amplifier does not require low temperatures for operation. It does have two channels of amplification, usually called the signal and idler channels, which are used simultaneously to obtain the low noise temperatures quoted above.

As a further comparison, the best reported low-noise microwave tubes have noise temperatures of about 300°K at 3000 megacycles, but have the advantage of single-channel amplification and electrical tunability.

The amplifier was designed and operated by Dr. R. C. Knechti and R. Weglein of Hughes Research Laboratories for the noise measurements and is related to the type of amplifier developed by Dr. Uenohara at the Bell Telephone Laboratories. With the noise temperatures of 50°K and 100°K obtained at liquid nitrogen and room temperatures respectively, the 3000-megacycle amplifier gives 30 db of amplification with two megacycles bandwidth or 10 db of amplification with 25 megacycles bandwidth.

Such amplifiers would, of course, be useful in many applications of microwave and UHF receivers where greater sensitivity or lower receiver noise is required.

The production models of the Hughes diode, designated HPA-2800 and HPA-2810 have a nominal cutoff frequency of 70,000 megacycles at maximum back bias with a nominal zero-bias capacitance of 2.5 mmf. Its noise performance is attributed to its low equivalent series resistance at microwave frequencies.

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MINIATURE ELECTRONIC TIME DELAY RELAYS 31200 SERIES

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Length	2 1/4" long	2" long
Weight	6 ounces	3 ounces
WRITE FOR:	Bulletin AWH TD-503	Bulletin AWH TD-504

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High Temperature: 125°C (250°F)
Vibration: 2000 CPS at 15 g.
Contact arrangements up to 4 pole double throw.
Unique transistorized R.C. time constant network.
Time Delays from 50 MS to 120 seconds. Longer Delays available.
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Radiation-Levinthal Merger Being Discussed

MELBOURNE, Fla.—Discussions are in progress to merge Radiation Inc. with the Levinthal Electronic Products Inc. Radiation is located near here, Levinthal at Palo Alto, Calif.

Levinthal will be a wholly-owned subsidiary and continue to operate under its present management. Each company will have a representative on the other's board of directors. George Shaw, vice-president of Radiation and Albert J. Morris, vice-president of Levinthal, will maintain technical cross liaison.

Radiation officials said that the merger was intended to broaden the base of their operation, largely telemetry and digital computing instruments now. Levinthal has been creating electro surgical, medical and nucleonic instruments.

. . . APT Robot

(Continued from page 33)

shape took just five hours by the APT method. Under manual programming, it required 200 man-hours. In general, say its developers, APT will permit man-hour reductions in the range of 80 to 95 per cent.

APT in its present form is not yet a panacea for the problems of intricate production in the space age, an industry representative stated. It must be further refined and it must be mass exploited.

• **Service tests**—First step toward putting it in wide industry use is a two-year program by the three participating groups to service test the equipment on actual production items. MIT is now preparing documentation to be distributed to the aircraft and missile and other industries.

It consists of six volumes with more than 600 pages of text, diagrams and charts. This, plus the language dictionary and the master cards, will permit any contractor who has possession of or access to a suitable computer (preferably but not necessarily the IBM 704 in wide industry use) to make parts through APT. The 19 member companies of AIA will introduce the system, and other companies will be invited to participate.

It is anticipated that actual production use of the equipment will develop a number of refinements in APT. They will be reported to the APT Project Coordinating Group of AIA's Numerical Control Panel, which will in turn make the results available to the Servomechanisms Laboratory and AMC's Manufacturing Methods Division.

• **Program's history**—APT is the latest step in a long research program on numerical control production methods. First numerically-controlled operations were started in 1952 and the scale on which they are employed in actual production has been climbing steadily since. Some plants developed interim automatic programming methods pending development of APT.

The cooperative APT program got under way early in 1957. First industry testing started last April, when MIT provided a field trial version

APT is itself an interim system. Although the electronic link between design and production has shaved programming man-hours to a significant degree, it has not completely eliminated manual programming. In future research on the system, MIT and its collaborators will look for new ways of shortening further the time and effort between design of a part and the cutting of metal.

contract awards

ARMY

$8,362,732—**Chrysler Corp.**, for the *Jupiter* program.

$6,700,000—**Lear, Inc.**, Grand Rapids, Mich., Div., for R&D on *Nike-Zeus* system (sub-contract from Bell Telephone).

$2,949,652—**Daniel Construction Co. of Alabama**, Birmingham, for construction of missions engineering building at Redstone Arsenal.

$1,721,189—**Robinson & Wilson**, San Bernardino, Calif., for guided missile vehicle assembly building for Project *Sentry* at Vandenberg AFB.

$1,341,357—**Cornell Aeronautical Laboratory, Inc.**, Buffalo, N.Y., for high-power microwave radar research program.

$1,140,000—**Rocketdyne Div., North American Aviation, Inc.**, for design and development (two contracts).

$925,484—**Radioplane Co.**, Van Nuys, Calif., for supplies and services.

$732,257—**American Machine and Foundry Co.**, for *Pogo-Hi* targets.

$631,981—**Whitaker Gyro Div., Telecomputing Corp.**, Van Nuys, Calif., for overhauling gyros.

$495,356—**B. B. Saxon**, Fort Walton Beach, Fla., for modifications and additions to buildings at Eglin AFB launching facility.

$448,000—**R. D. Lowman General Contractor, Inc.**, El Paso, Tex., for *Nike-Zeus* LAR receiver annex and R&D site work.

$378,900—**Harvey Aluminum, Inc.**, Torrance, Calif., for fuses.

$234,214—**Western Electric Co., Inc.**, for electron tubes.

$218,526—**Western Electric Co., Inc.**, for *Nike* spare parts and components (four contracts).

$212,524—**Radioplane Div., Northrop Aircraft, Inc.**, for amendment of basic contract to provide additional services, engineering changes and certain product improvements.

$155,653—**Douglas Aircraft Co., Inc.**, for launching area items and repair parts.

AIR FORCE

$6,000,000—**Marquardt Aircraft Co.**, for RJ43-MA-11 ramjet engines for *Bomarc* program.

$3,000,000—**Lear, Inc.**, Grand Rapids, Mich., Div., for coordinate converter systems for *Bomarc* (follow-on order from Boeing).

$2,283,120—**Convair (San Diego) Div.**, General Dynamics Corp., for design, construction and installation of an automatic data handling system for the Wright Air Development Center.

$950,610—**Westinghouse Electric Corp.**, for electron tubes.

$731,996—**Philco Corp.**, for technical services (two contracts).

$486,300—**General Motors Corp.**, for technical services.

$316,000—**RCA Service Co. Div.**, for technical services.

$100,000—**Harvard College**, for study of fundamental physics of ferromagnetic and ferroelectric materials.

$95,000—**Stanford University**, for investigation of microwave properties of plasmas.

$88,400—**National Scientific Laboratories, Inc.**, Washington, D.C., for technical services.

$65,600—**North American Aviation, Inc.**, for technical services.

$80,000—**University of Illinois**, for continued research on "Diffusion in Semi-conductors and Related Problems."

$31,515—**University of California**, for "Study of High-Precision Geocentric and Interplanetary Orbits."

$55,000—**University of Maryland**, for research on "Rapid Cosmic Ray Variations and Solar Effects."

NAVY

$94,540—**Pennsylvania State University**, for research on aluminum hydride and related hydride.

$93,732—**Aerojet-General Corp.**, for modification of *Aerobee 100, 150 and 300* sounding rockets.

$86,446—**Princeton University**, for research in heat transfer from ionized gas to a gaseous coolant.

$88,150—**The Franklin Institute of the State of Pennsylvania**, for development, design and fabrication of 52 vertical scale indicators.

$71,494—**Vertol Aircraft Corp.**, Morton, Pa., for research on rotating wing aerodynamics.

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Senior Design Engineers or Specialists. BA or MS or equivalent. These men should be conceptual rocket engine designers with experience in turbopump or high speed rotating machinery layouts and familiarity with combustion devices. They should be creative designers, oriented toward preliminary design.

Please write to Mr. D. C. Jamieson, Engineering Personnel Dept., 6633 Canoga Avenue, Canoga Park, Calif.

ROCKETDYNE
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FIRST WITH POWER FOR OUTER SPACE

west coast industry

by Fred S. Hunter

Weapon system tests of Convair's new F-106A got off to a fancy start at the White Sands missile range when two GAR-3 *Falcons,* the first guided air rockets to be launched from the advanced interceptor using the new Hughes MA-1 fire control system, scored direct hits on a parachute target. The MA-1 fire control system is capable of flying the F-106 throughout the entire interceptor mission from detection to destruction of the target, leaving the pilot free to make tactical decisions, and the GAR-3 flies faster, climbs higher and knocks down targets at longer range than previous Hughes *Falcons.*

GAR-3 improvements include a nose cone that is longer and more pointed than the stubby, rounded radomes of the GAR-1D and GAR-2 rockets which comprise the armament of the currently operational Convair F-102 interceptors. It is of a plastic material which Hughes says represents a significant development of nose cone material capable of withstanding a great variety of environments created by speed and temperatures and enables the *Falcon* to adjust to these environments in fractions of seconds.

Industrial Association of the San Fernando Valley, encouraged apparently by the location of the new Thompson Ramo Wooldridge research center on rezoned agricultural land in the area followed by RCA's acquisition of a 50-acre site for a missile and radar center, has filed two tract maps with the city on 500 acres which might serve a similar purpose, and is considering 14 possible areas in all. The association estimates research and development centers might add $100 million to the valley's annual payroll.

Dr. H. V. Neher, Caltech physics professor and a member of the U.S. IGY panel on cosmic radiation, explains why balloons are preferred over rockets for studies of cosmic distribution. They give several hours of measurements instead of a few minutes, and the ionization chambers they carry aloft give better statistics than rocket-borne Geiger counters. Dr. Neher notes that there is increasing evidence that cosmic rays do not come from the sun, but possibly from the stars or distant galaxies. And more study is needed to determine whether the so-called Van Allen belts of radiation around the earth are caused by cosmic rays or particles from the sun.

John Marschalk's resignation as executive director of the Strategic Industries Association came as a surprise to many of us. He's been the personification of the association since its organization in 1954. But he will be available as a consultant and objectives of the group are unchanged, says Harvey Riggs, president of International Electronic Research Corp., who recently took over the SIA presidency, succeeding Ted Coleman, president of Coleman Engineering Co.

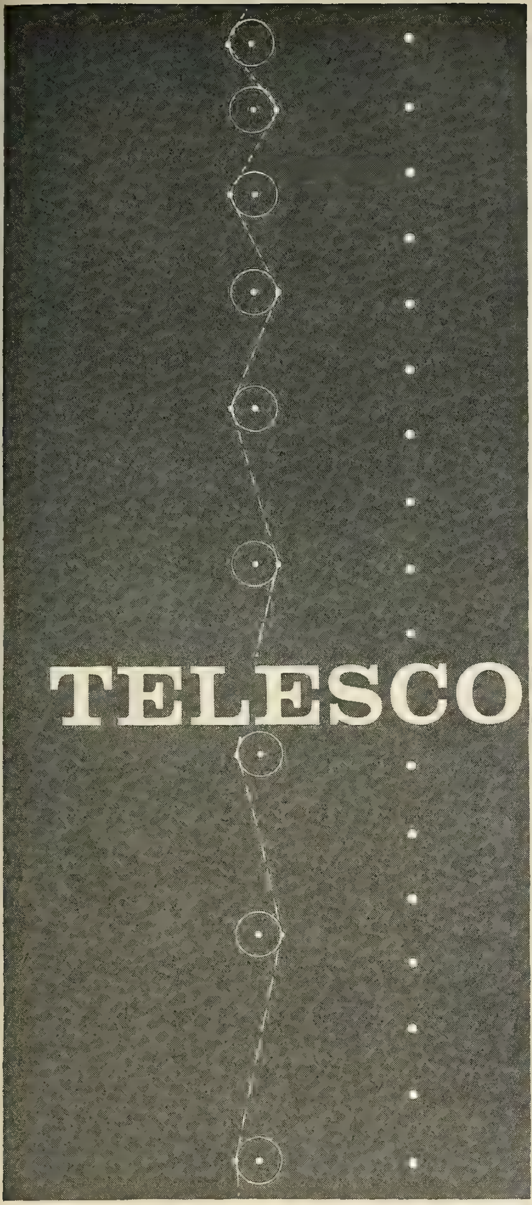
Riggs hopes to see SIA's membership, now about 90, expand to 300 or 400 firms in the immediate future. Most of the 90 paying dues now are located in the Los Angeles area. Riggs wants to spread out nationally. He has his eye, particularly, on San Francisco Bay and the area around Washington. Meanwhile, SIA is looking around for a successor to Marschalk. It needs a man who knows his way around the Department of Defense.

WS-131B is weapon system designation for North American Aviation's *GAM-77* (also known as the *Hound Dog)* for the Boeing B-52G. If you are curious as to what may have been the *WS-133A*, you can relax. There never was a *WS-131A* beyond a few pieces of metal.

Paints for aircraft and missiles now make up a $1-million-a-year business for W. P. Fuller & Co. Sample missile product—a special heat-resistant paint for the *Explorer I.*

Did you know that T. Keith Glennan, administrator of the National Aeronautics and Space Administration, was a sound expert in the Hollywood movie studios before World War II? . . . And that since Vandenberg AFB became operational, the daily newspaper at Santa Maria proclaims in its masthead that it is the "Missile Capital of the Free World"?

ENGINEERS–SCIENTISTS



Engineers and Scientists at Republic Aviation—with a turn for dry professional humor—say that they're asked to solve every problem of upper atmosphere and space flight with the factor

$$\sqrt{1-\frac{V^2}{C^2}}$$

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when and where

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Third Annual Shock Tube Symposium, Old Point Comfort, Ft. Monroe, Va. March 10-11.

Support Equipment Institute, Organizational Meeting, Statler Hotel, Washington, D. C., March 12.

American Society for Metals, 11th Western Exposition and Congress, Pan-Pacific Auditorium and Ambassador Hotel, Los Angeles, March 16-20.

The American Rocket Society, 1959 Sectional Meeting, Daytona Plaza Hotel, Daytona Beach, Fla., March 23-25.

Institute of Radio Engineers, National Convention, Coliseum and Waldorf-Astoria Hotel, New York, March 23-26.

Society of the Plastics Industry, 16th Annual Conference, Pacific Coast Section, Hotel del Coronado, San Diego, March 25-27.

American Society of Mechanical Engineers, Instruments and Regulators Division Conference, Cleveland, March 29-Apr. 2.

Society of Automotive Engineers, National Aeronautic Meeting, Hotel Commodore, New York, March 31-Apr. 3.

APRIL

Conference on Electrically Exploded Wires, sponsored by the Thermal Radiation Laboratory of the Geophysics Research Directorate of the Air Force Cambridge Research Center, Somerset Hotel, Boston, Apr. 2-3.

American Society for Quality Control, Portland Chapter, Oregon Museum of Science and Industry, Portland, Apr. 3-4.

1959 Nuclear Congress, Municipal Auditorium, Cleveland. For information: Engineers Joint Council, 29 West 39th St., New York. Apr. 5-10.

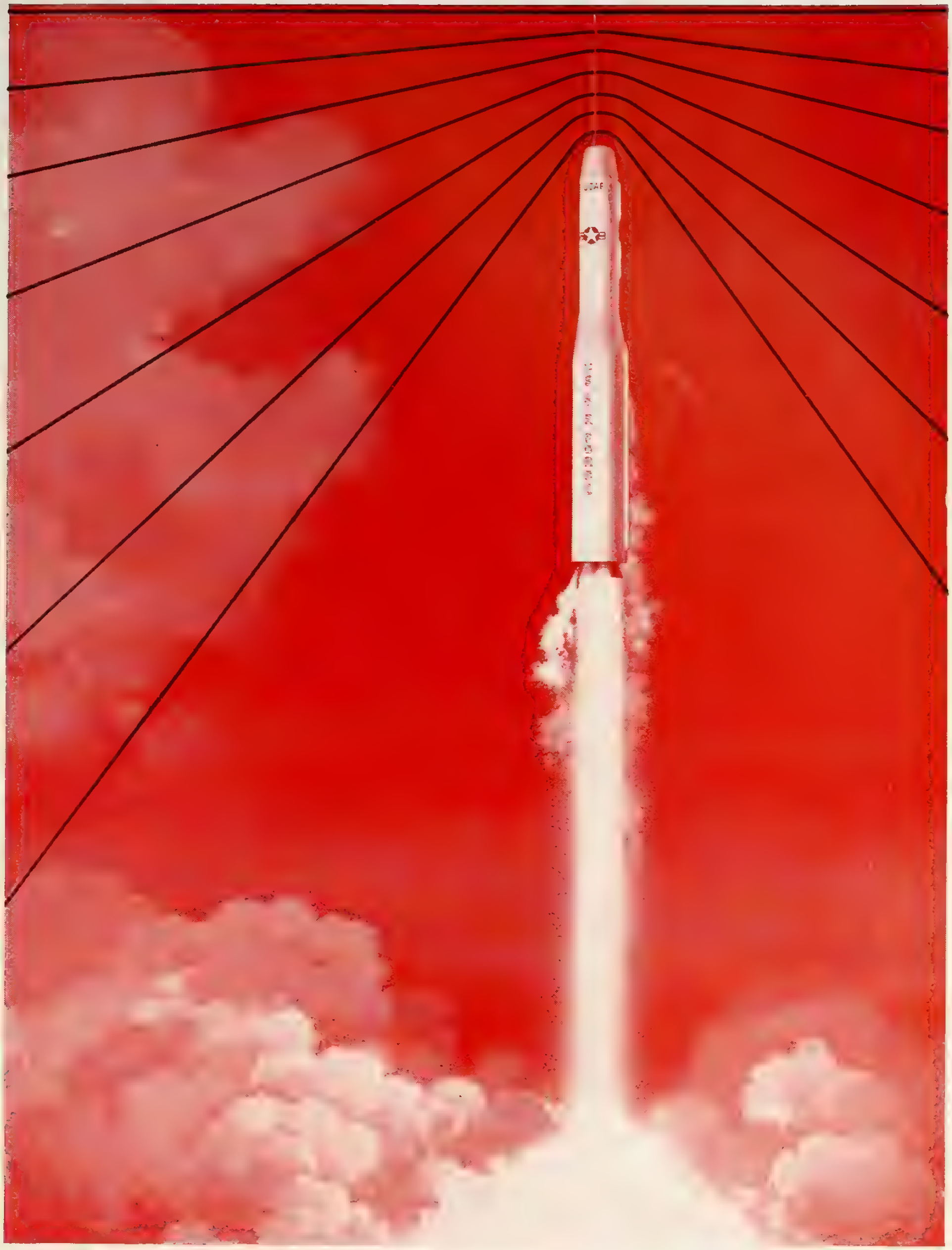
American Welding Society, 1959 Welding Show and 40th Annual Convention, International Amphitheatre and Hotel Sherman, Chicago, Apr. 7-10.

Air Force Association, World Congress of Flight, Las Vegas, Nev., Apr. 12-19.

Aeronautical Training Society, 17th Annual Meeting, Las Vegas, Apr. 16-17.

American Society of Tool Engineers, Annual Meeting, Schroeder Hotel, Milwaukee, Apr. 18-22.

American Rocket Society, Man-in-Space Conference, Hotel Chamberlain, Hampton, Va., Apr. 20-22.



Titan nose cone from Avco — The recent flight of the Air Force Titan ICBM was achieved by the free world's most advanced rocket technologists. Avco scientists and engineers, pioneers in missile reentry work, are members of the Titan team. They are contributing a reentry vehicle designed to withstand the scorching friction during the reentry phase of the ICBM's planned intercontinental range flight. And now, Avco has been chosen as the associate contractor for the reentry vehicle of the next Air Force ICBM . . . the mighty, solid-fueled Minuteman.

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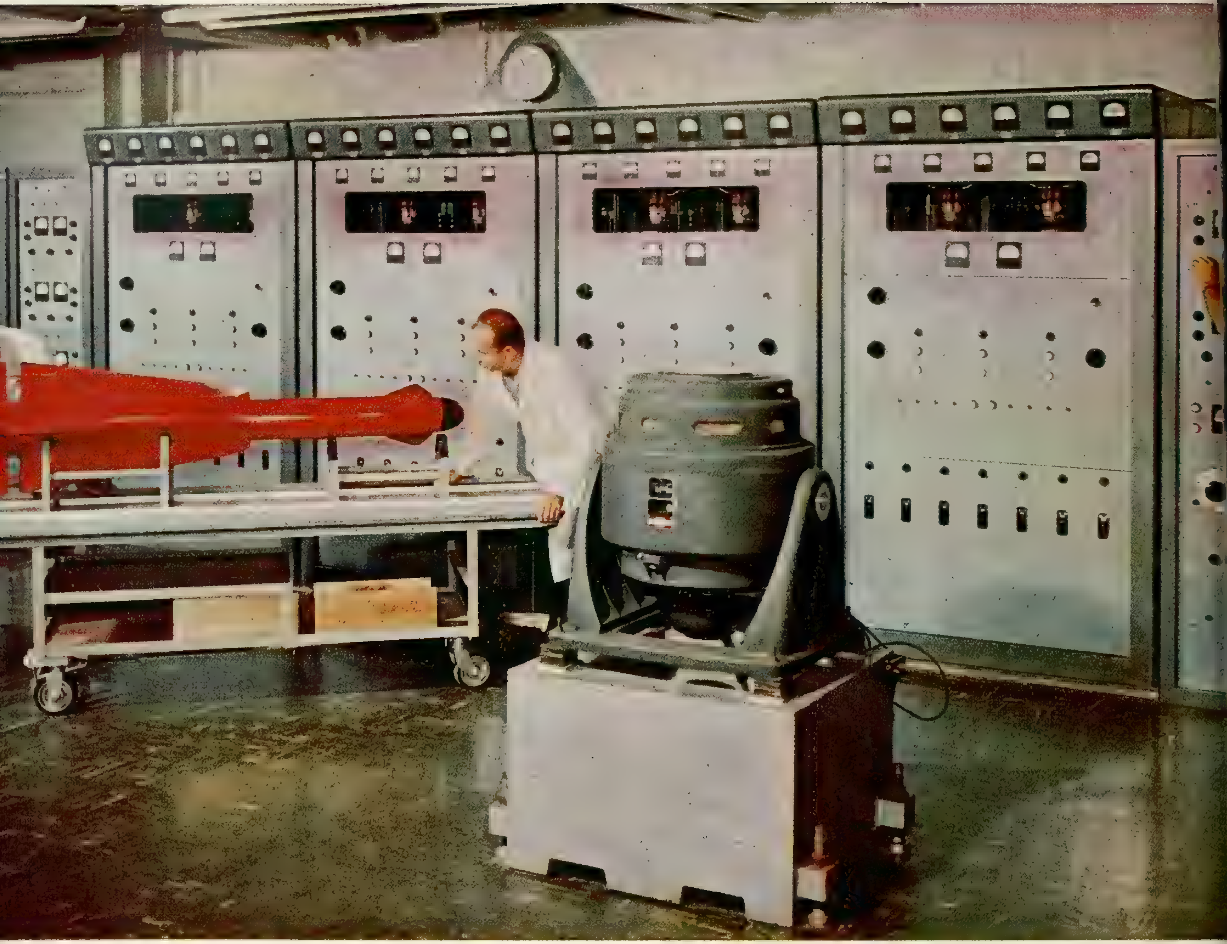

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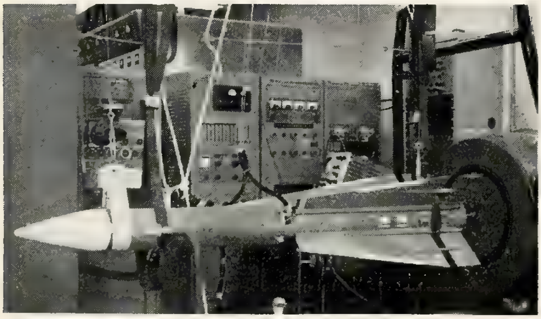

Vibration testing a GAR-3 on a Ling System

Overcoming destructive vibration forces is an important part of reliability determination at Hughes Aircraft Company.

Both individual components and complete packages such as this production model Falcon (GAR-1D), are qualified through a continuing program of environmental vibration testing, using the many Ling Vibration Systems installed at Hughes.

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MARCH 16, 1959

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missiles and rockets

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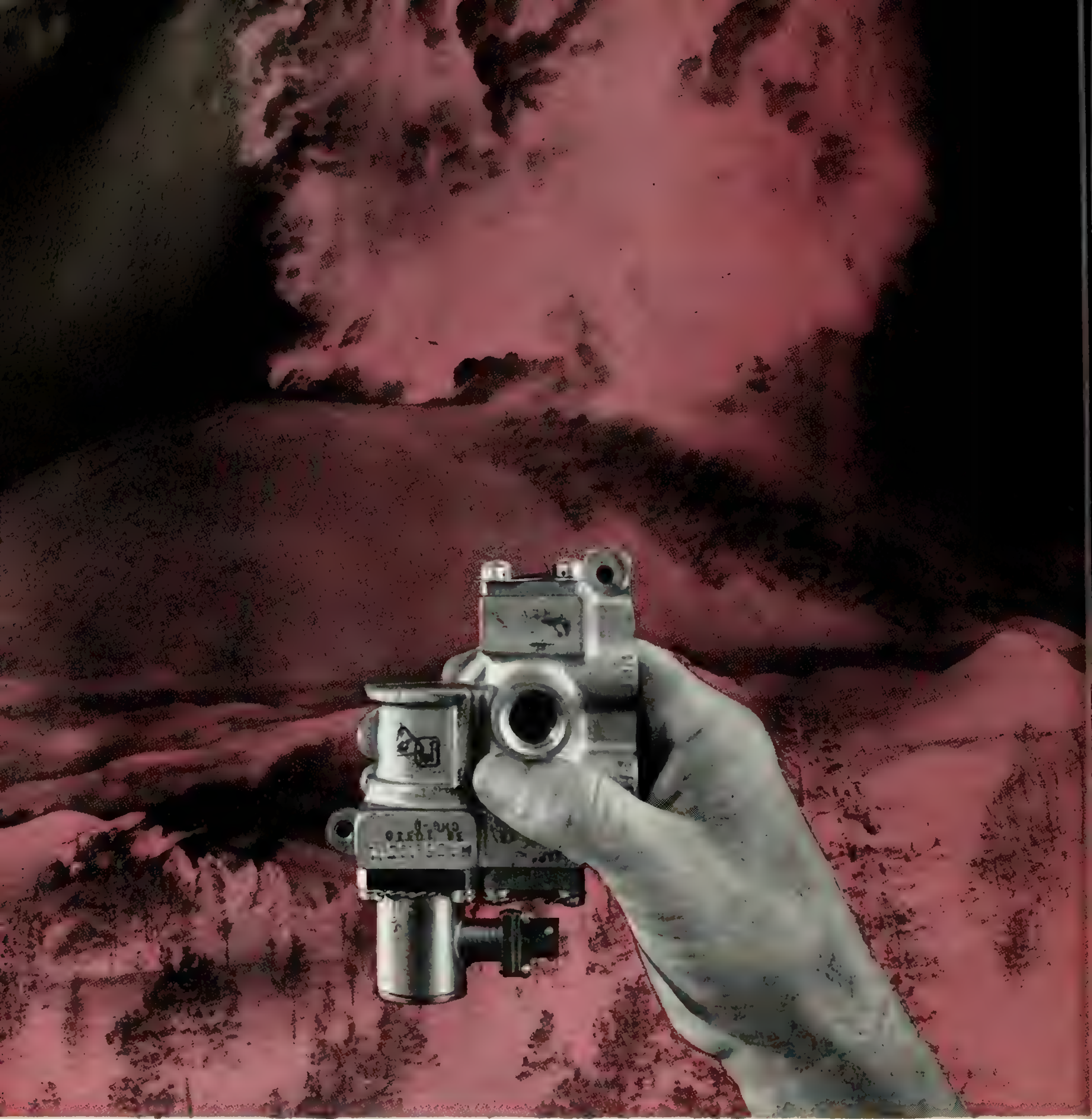

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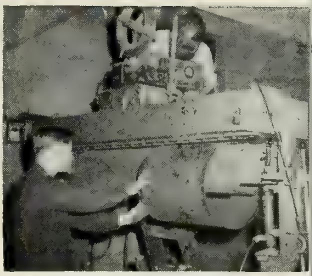

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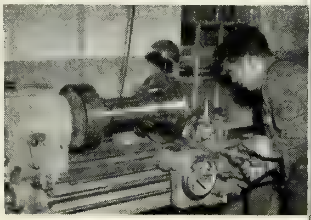

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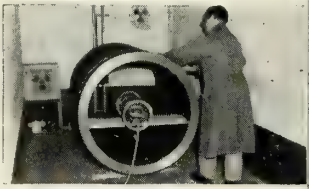

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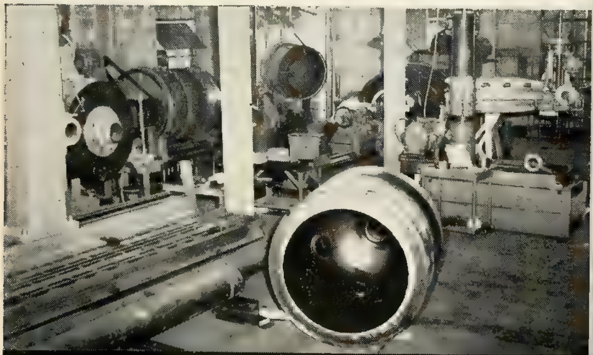

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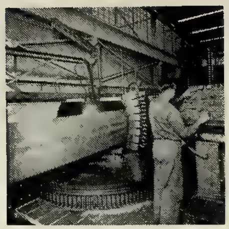
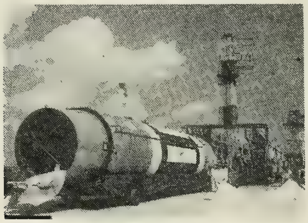


COVER: Alloys for *Atlas* are formed with Bath Company's "skin-stretching" machine. (p. 24)



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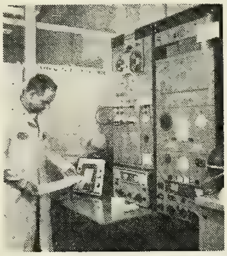
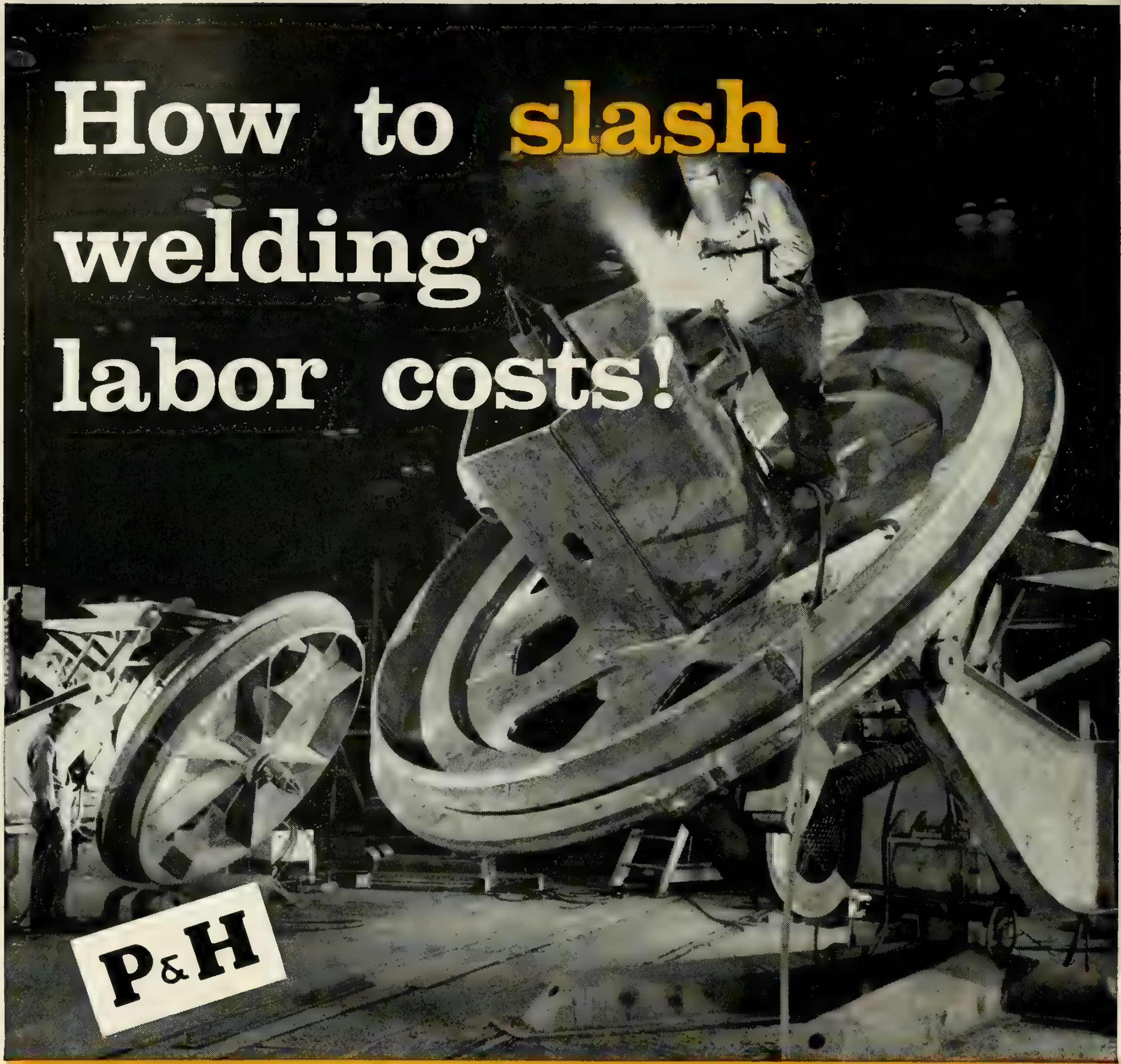


SOHIO'S tracking station is getting valuable data with simplified equipment. (p. 29)

BEING used in a nuclear reactor is paraffin-lead which has future application for space vehicles. (p. 34)

RADOME costs may be reduced by new spraying technique of Gladding, McBean & Co. (p. 37)

How to slash welding labor costs!



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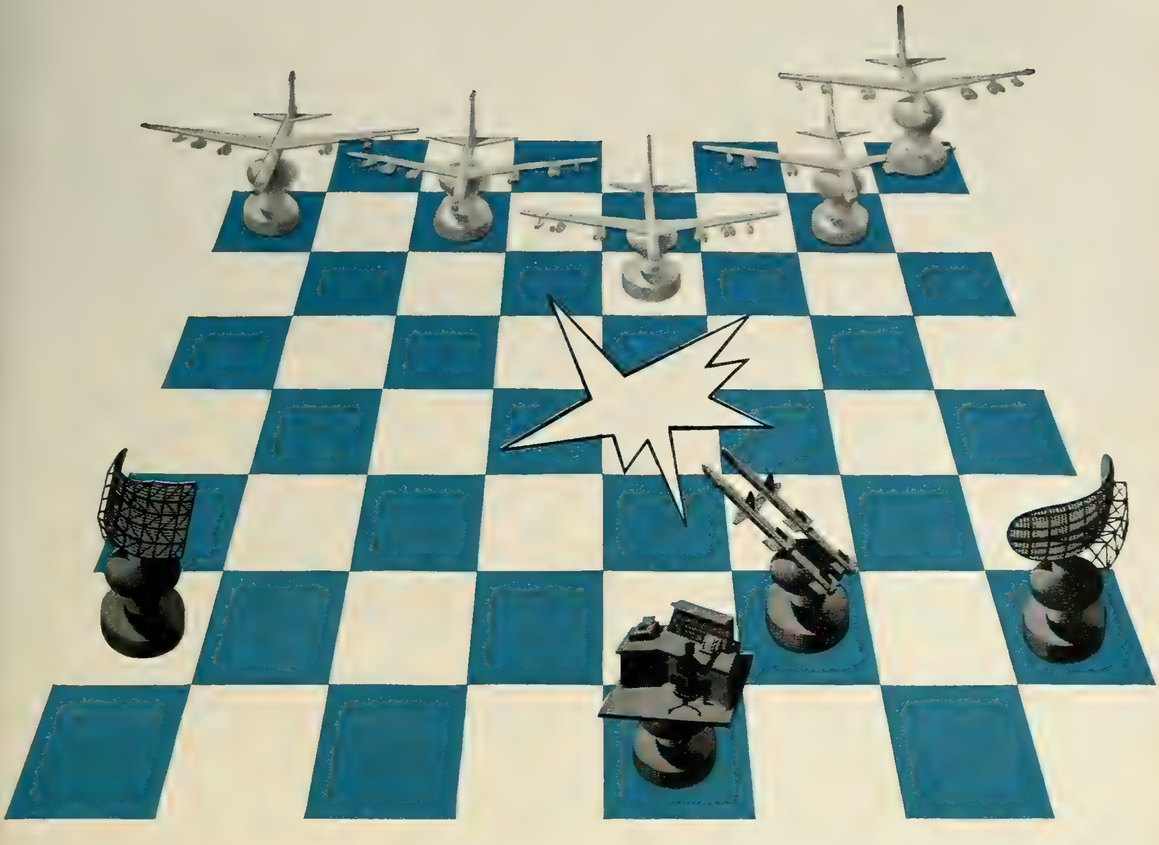

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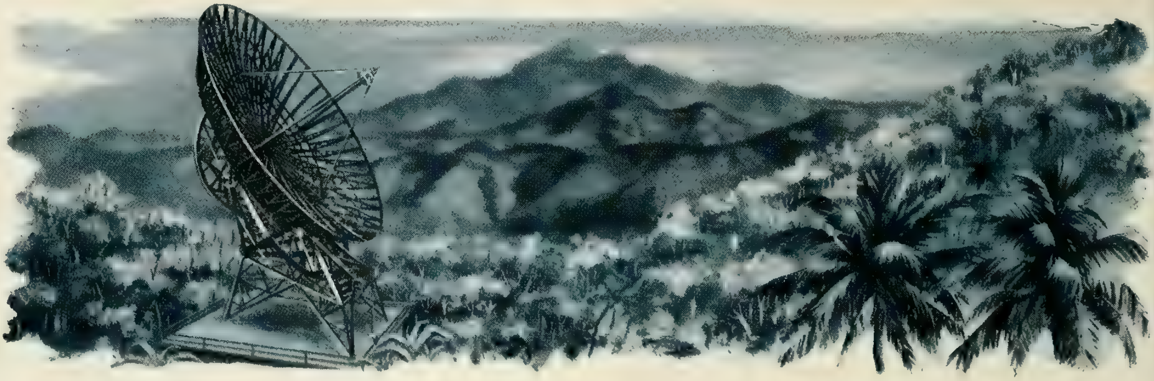

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Progress Report

Over the past year it has become more and more apparent that the Department of Defense, other agencies of the United States government and aircraft, missile and electronics manufacturers have been placing more and more emphasis upon the systems concept for weapons and space flight development.

In order to keep pace with the evolvement of this concept, and to remain a true industry medium for all those who design, develop, test, manufacture and operate missiles, rockets and space vehicles, and their supporting equipment, *Missiles and Rockets* has been gradually broadening its editorial scope with more and more attention to the systems approach and a consequent and necessary increase in the amount and caliber of technical editorial coverage.

Furthermore, while *Missiles and Rockets* will always believe it an obligation to champion any cause or program which will further the nation's defense and space development capabilities, *Missiles and Rockets* will scrupulously avoid the undue influence of any individual association, group or service.

Missiles and Rockets' current editorial expansion plan, now all but completed, is under the direct supervision of Clarke Newlon, who was appointed executive editor on September 2, 1958. It calls for a staff of 12 full time editors, 12 contributing and regional editors, 12 correspondents, and an eight-man editorial advisory board.

Among the recent appointments by Mr. Newlon as full time editorial staff members are:
Charles LaFond, formerly Page Electric Co., electronics engineering.
Hal Gettings, formerly Radiation Inc., electronics and support equipment;
Allan D. Seltzer, formerly Redstone Arsenal Research and Development, chemical engineering and weapon systems;
William Hall, Washington Industrial Public Relations and formerly UPI—government agencies;
William Howard, formerly United Press International, missile and space industry;
James Baar, formerly United Press International, military and weapons systems.

Added as contributing staff members on a regular basis are: James J. Haggerty, Jr., authoritative aero/space writer; and Michael Lorenzo, advisor to the U.S. Air Force on propulsion.

In its 30 months of publication since October, 1956, *Missiles and Rockets* has grown from a revolutionary idea on the horizon of the business publishing field to an extremely successful and vital weekly magazine. In 1958, among the some 2700 listed business publications of all types in the U. S., it ranked 63rd in advertising volume, a record possibly unmatched in all business publishing history. During the past several years it has scored time and again with exclusive news and technical reports in the missile and space flight fields; it has carried more editorial pages devoted to those subjects than any other magazine of any type.

Enthusiastic support from all phases of industry made it possible for *M/R* paid circulation to grow to 29,997 for the last issue of 1958, subject to ABC audit; it carried 1686 pages of advertising in its second full year of publication, far more than any other business publication covering the same market.

In a recession year when business publications as a group showed a 14% revenue loss, *M/R* showed a 58% gain over the previous year, the largest of any publication reporting to Industrial Marketing magazine. Revenue for the first two months of 1959 increased 43% over the same period of 1958.

In short, *Missiles and Rockets* has telescoped a normal business publication growth of some 20 years into a period one-tenth as long. It has pioneered a totally new concept of market coverage, causing a major revolution within its field. It has kept pace with a market which has grown from $21 million to $7 billion in just eight years.

As another major move to strengthen the organization behind *Missiles and Rockets,* Edward D. Muhlfeld, advertising sales manager since the magazine's founding, has been named Assistant Publisher with headquarters in Washington. Walton E. Brown, regional advertising manager in Los Angeles, has been named advertising sales manager with headquarters in New York. With editorial and advertising performance measured by the Eastman and Mills Shepard Research organizations, *Missiles and Rockets* will strive for a maturity calculated to provide for its readers a true industry medium deserving of its description, namely, the technical news weekly of the missile/space industries.

Wayne W. Parrish
Publisher

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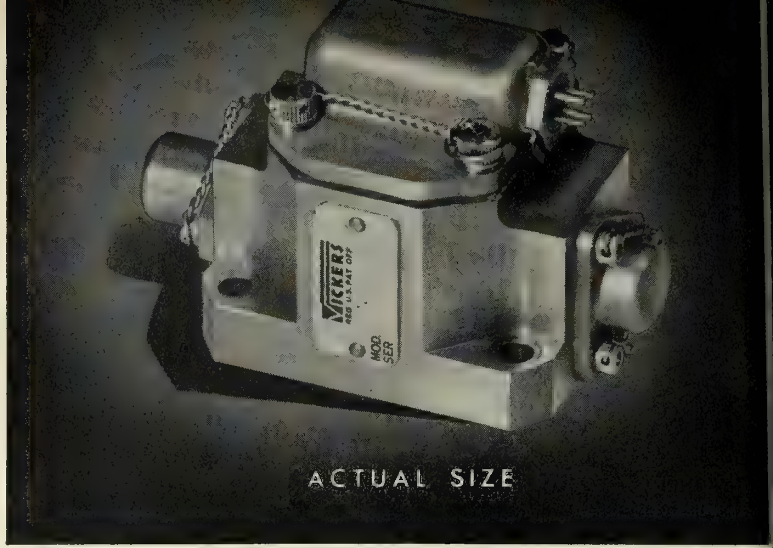

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washington countdown

Pioneer IV and *Mechta* . . .

comparison works out like this (*Mechta* in parentheses): Weight, 13.4 lb (796.5); moon miss, 37,000 miles (4,660); time tracked, 84 hours (62); distance tracked, 406,020 miles (370,000); perihelion, 91,744,000 miles (91,500,000); aphelion, 105,829,000 miles (123,250,000); velocity at perihelion, 69,500 mph (72,360); velocity at aphelion, 60,000 mph (54,360); time of orbit, 392 days (447).

DOD confirmed *Discoverer I* . . .

orbit (m/r, March 9, p. 20) after press deadline. Some 41 tracking reports were received verifying the orbit. Life expectancy is 30 days with apogee of 519 and perigee of 176 statute miles.

France's Saharian . . .

test range of Colomb-Bechar has started the first of 50 scientific rocket firings using *Veronique* and *Monica* birds. Under sponsorship of newly-created French Space Committee, rockets will explore at altitudes between 30 and 150 miles.

British missiles only . . .

interest the Australian Navy insofar as their surface units are concerned. While very interested in *Sidewinder* and other air-launched missiles, the Australians say problems of training personnel and acquiring experience with American guidance and support equipment give the advantage to British-made missiles. The Australians are reported considering several, including *Seaslug*.

In missile management . . .

investigation by House Military Operations Subcommittee, Assistant DOD Secretary Quarles came to the defense of the Institute for Defense Analyses (m/r, Jan. 5, p. 20). Quarles said IDA is limited to technical advice and has no power to select a specific contractor. IDA has 30 non-government staff members, he said, and operates on a non-profit basis.

Legislation to reinstate . . .

the excess profits tax of 1950 has been introduced by Sen. Richard L. Neuberger (D-Ore.). The bill would reimpose the tax for the taxable years beginning July 1, 1961.

Merger of Navy bureaus . . .

is again being rumored in Washington. Plan to merge the Bureau of Aeronautics and the Bureau of Ordnance into a Bureau of Weapons has been reported before. Navy would only say that no definite decision in the matter has been made.

Renegotiation Act probe . . .

will have to take a back seat, according to reports from the Hill, with discord over extension of unemployment compensation nosing the Renegotiation Bill out of first place on the agenda of the House Ways and Means Committee.

Renegotiation . . .

has been left out of a procurement bill introduced by Rep. William Bates (R-Mass.). That's its only real difference from a procurement bill introduced by Sen. Leverett Saltonstall (R-Mass.). Both bills would put negotiation on a par with advertised bidding and permit use of the technique termed "competitive negotiation." Another section would give specific authority and guidelines for use of the weapons system—redefined as "operational system."

Zeus production . . .

commitment is far from settled one way or the other with Congress hearing from Army R&D Chief Trudeau that it is "our only hope for the early 1960's." DOD's Holaday said he concurs at maintaining program at present R&D level but wants another $40 million for engineering development work. JCOS have said they think Army money for air-to-surface missiles is "substantially below" recommended 1960 needs, and that AF needs more money for *Bomarc* procurement.

Supplemental FY 1959 . . .

appropriation of $48,350,000 has been approved by the Senate for NASA. Most is for R&D on *Project Mercury* ($20,750,000) but there's $24,250,000 for construction and equipment.

CAN SYNCHROS BE MOISTURE-PROOFED?

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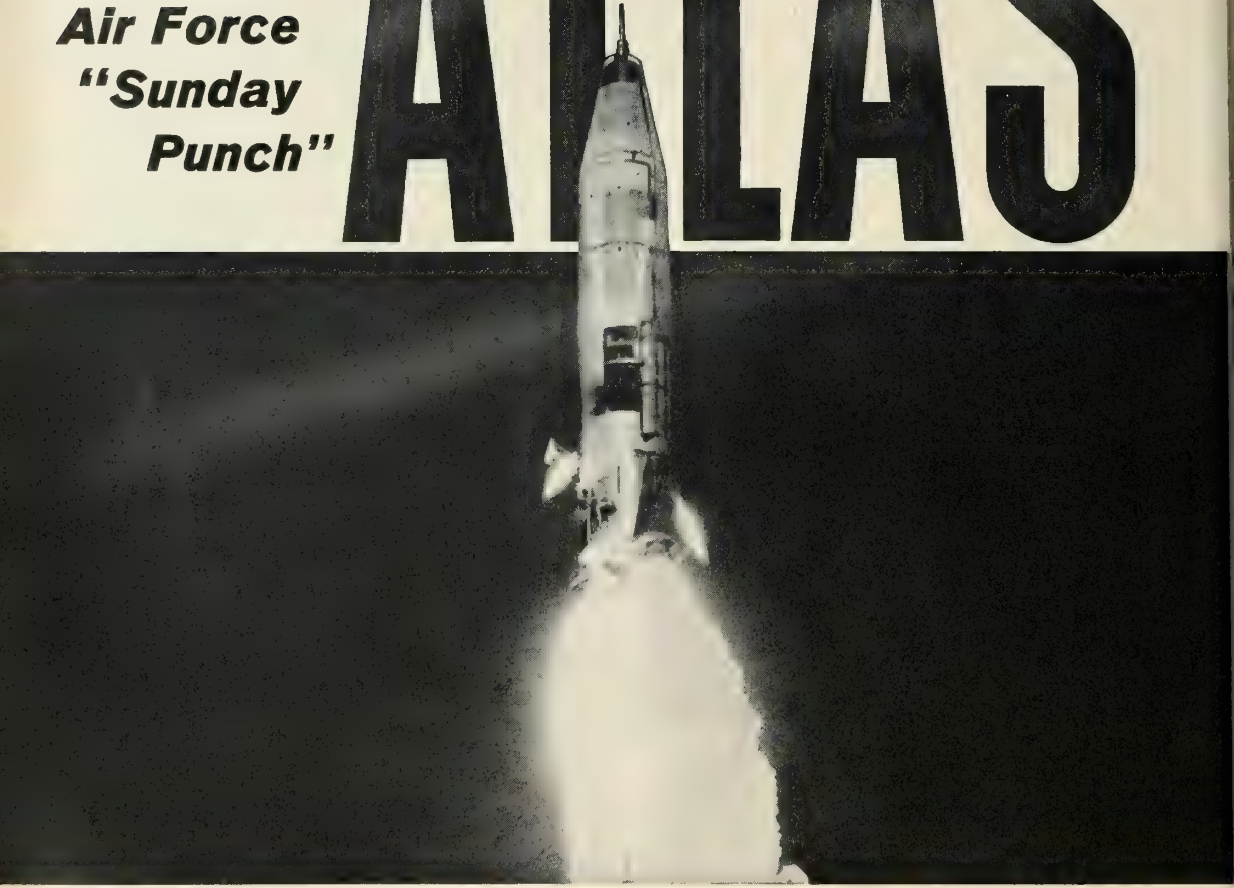
ATLAS

Air Force "Sunday Punch"



Boosted into space by the fiery thrust of three huge rocket engines, the seven-story Atlas intercontinental ballistic missile roars upward from its Cape Canaveral launching pad. Quickly it sheds the frost encrusting the liquid oxygen tank and races to its predetermined destination in the far reaches of the globe. In its size and range and capability, the Air Force Atlas is a commentary, for all the world to heed, of the necessity to maintain the peace. RCA's Missile and Surface Radar Department has been privileged to design and develop ground check-out, launch control and cabling equipment as a major subcontractor to Convair (Astronautics) Division of General Dynamics Corporation, the Atlas prime weapons systems contractor.

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DEFENSE ELECTRONIC PRODUCTS
CAMDEN, N. J.

industry countdown

Decision on ALBM . . .

contractor will be made about April 15. Sixteen firms have put in proposals out of 20 called in. Earlier R&D feasibility studies (WS-199B, m/r Dec. 1, p. 11) were made by Martin, Lockheed-Convair and McDonnell. On the engine, all three want Thiokol. Martin's subcontract system would be Thiokol, General Precision Equipment Corp., Librascope, Inc., Kearfott Co., and Kollsman Instrument Corp., guidance.

30,000-pound solid . . .

booster for a manned space capsule is unofficially being pushed by Grand Central Rocket Co. Company says it would have less than 2 g's acceleration compared with 6 g's for *Atlas*. So far design is only on paper. Company also says it can put a four-stage solid propellant space vehicle on a launch pad within four years at a cost of $70 million compared with $102 million, which Grand Central says is needed for a 1.5-megaton single-chamber liquid booster.

Minuteman R&D propulsion . . .

contracts totaling $162 million have gone to Aerojet and Thiokol. Latter's work under $77 million contract will be at Brigham City, Utah. Aerojet-Azusa will research under $85 million award. AF has announced seventh site for ICBM near Lincoln AFB, that could be model for *Minuteman*, which may be accelerated by as much as six months, according to Lt. Gen. C. S. Irvine.

First *X-15* glide test . . .

is due this week at Edwards AFB to be followed by powered flight. *X-15* last week rode on a special pylon under right wing of modified B-52 for first captive flight test.

Major *Polaris* missile . . .

and submarine system contracts now total 440. Missile system contracts, including guidance account for 140, but some 4000 vendors are involved in the FBM program.

DOD will have . . .

available this week a study for the Labor Department to determine how much of the missile dollar goes to manufacturers of airframes, electronics and propulsion. While the Holaday report will not be exact, it should help to resolve the question of a redefinition of aircraft to include missiles and missile electronics. AIA wants the redefinition, EIA opposes it.

Convair has a "task force" . . .

studying use of *Lobber* as an anti-submarine weapon for depth charging or placing of sonobuoys and flares.

Air Force has biggest piece . . .

of the missile obligations for the six-month period ending Dec. 31. Breakdown for the first half of FY 1959 shows: Army, $4.3 million; Navy, $4.1 million; Air Force, $1.45 billion, for a total of $2.3 billion. Missile expenditures in December were $2.8 million, for a six-month total of $1.5 billion.

$61.8 million contract . . .

has gone to McDonnell for F-4H-1 airplanes. They will be armed with *Sparrow III*, and will be partially recessed into the fuselage for supersonic flight.

Vanguard II's cloud cover . . .

instrumentation transmitted 250,000 ft. of taped signals, but because of an unexpected precession of the satellite, it will take Army Signal Corps scientists months to decode the signals.

NASA's Scout will cost . . .

in the neighborhood of $500,000 per vehicle. This is less than $15 per pound for the total vehicle, and less than $3,500 per pound orbited.

Solid propellant . . .

escape rocket contract for *Mercury* capsule has been awarded Grand Central Rocket Co. by McDonnell Aircraft, prime. It's the first NASA project to go to the Redlands R&D center.

HUNTER-KILLER

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NTDC'S* ANTI-SUB TACTICS TRAINERS BY ERCO;
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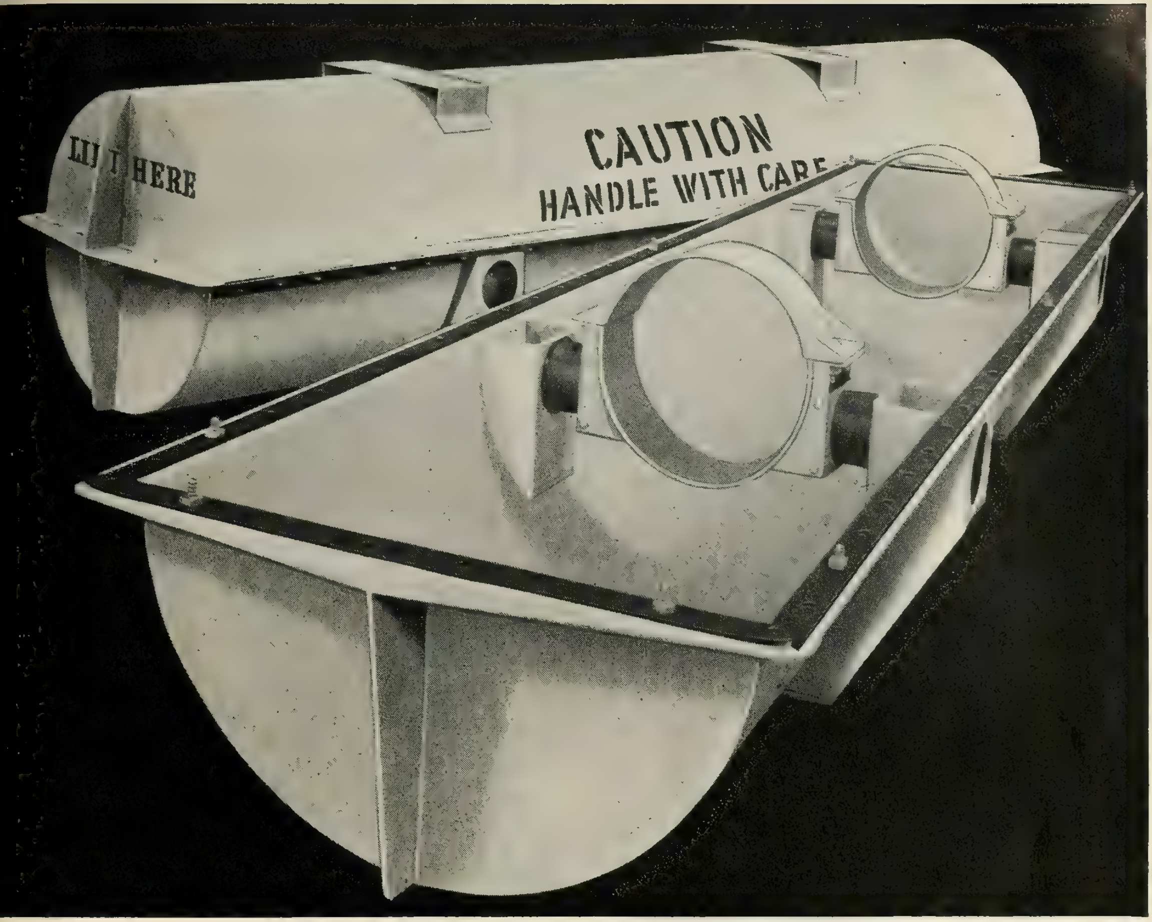


Shipping and storage container for solid propulsion unit produced by the Thiokol Redstone Division.

METAL FABRICATION PROBLEMS?

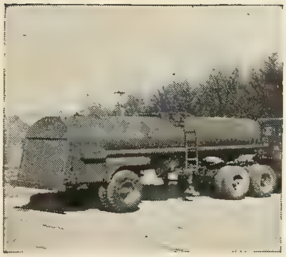
better see Butler

Prime contractors and major sub-contractors in government missile programs find the fastest and most economical way to solve metal fabrication problems is to turn them over to Butler.

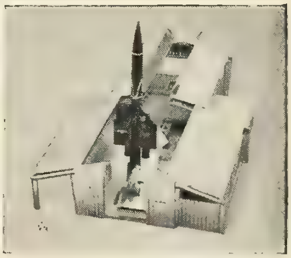
One of the largest fabricators of aluminum and steel with 7 strategically located plants, Butler has proven capability to design, engineer and deliver complex single units or volume production.

Butler is currently producing reusable metal shipping and storage containers for missiles and missile components, and also mobile fuel service units for the Redstone and Jupiter. Butler is participating in developing and producing the first shelters for Bomarc.

For a comprehensive picture of Butler's capabilities and facilities, write:



Water-alcohol fuel service unit for Redstone. Research, design testing and fabrication by Butler Contract Manufacture Division.



Butler was prime contractor for designing, developing, fabricating and erecting prototype Model III Bomarc launching shelter.

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NEW VOUGHT CRUSADER FOR FLEET NEXT YEAR!

Navy orders fourth version of flexible, economical fighter

For the fourth time in three years, a new *Crusader* type is extending the power of the Fleet. Chance Vought's F8U-2N has been ordered by the Navy for delivery next year. It will deploy alongside the Navy's swiftest photoplanes and two first line day fighters — all *Crusaders.*

The F8U-2N is another step in *Crusader* growth. Speed of this newest version has been advanced to near Mach 2. It will carry the deadliest air-to-air missiles. It is instrumented and radar-equipped for supersonic combat in darkness or bad weather.

This will be a new capability for the Fleet. Yet it is being acquired at low risk and cost. The F8U-2N's basic design has been proved simple, serviceable and economical . . . compiling an enviable performance record in a year of foreign duty with two Fleets.

Again, the growth provisions of the Vought *Crusader* have provided immediate, low-cost upgrading of the Fleet's aircraft inventory.

CHANCE VOUGHT AIRCRAFT
INCORPORATED · DALLAS, TEXAS

MARCH 16, 1959—VOL. 5, NO. 11

Transistors vs. Tubes

. . . are arbitrary military design specifications jeopardizing U.S. security?

by Donald E. Perry

WASHINGTON—Arbitrary military design specifications which call for complete or nearly complete transistorization of missile electronic equipment are placing the nation's defense system in jeopardy, industry officials have told m/r

And if another nation should strike first with nuclear weapons, there is widespread doubt in the industry that this country could effectively retaliate, with many aircraft and missile systems said to be virtually useless.

Industry and the military are differing on the merits of the vacuum tube vs. the solid-state devices such as the transistor and diode. Industry's point is that not enough research is being carried out to determine if the highly touted transistor can survive and perform satisfactorily while going through fields of nuclear radiation.

And with suspension of atomic tests many scientists feel a conclusive decision has not and cannot yet be made in favor of either the tube or the solid-state device.

It's obvious that radiation causes changes in the physical and chemical nature of components traveling through such fields. U.S. research today is aimed at how much it changes, and most important, how it affects a particular missile or aircraft circuit.

• **Stability lost**—Present research, m/r has been told, indicates that transistors in high neutron fluxes are not stable because of physical changes in their nature. This particularly applies to the audio-type transistors. Research has shown, however, that the thin-based high-frequency transistors "suffer less" from radiation effects.

This has led many weapon systems designers to believe strongly that the action of a transistorized system entering a cloud of primary and secondary fission products would be completely unpredictable.

While industry agrees with the military that the use of transistors should be pushed because they are lighter, require less power, and generate less heat, industry believes it's to the detriment of the nation that military design specifications in many cases require *complete transistorization* of equipment.

• **Services differ**—What's being done? The Navy, m/r has been told, has adopted a radically new procedure which says, in effect, that in the *Polaris* program vacuum tubes and solid-state devices will be given an "equal shake."

The Air Force, on the other hand, is still insisting on solid-state devices in most design specifications, m/r has been told. One instance was cited involving automatic test equipment using only solid-state devices. The equipment still has not been demonstrated after three years of work.

Here are other cases reported to m/r:

• A Navy missile was partially transistorized to test the reliability of transistor usage. It reportedly required 40 transistors to replace five vacuum tubes in order to overcome the lower performance of the transistor units.

• A top designer of a company manufacturing autopilots for aircraft said he "shudders to think of using transistors in autopilots because they are so unstable." He said he must compromise his design to use transistors because he has no choice—the military is demanding transistorized units. He pointed out that there is a real danger to life and property involved because autopilots designed with tubes include fail-safe mechanisms whereas those using transistors normally do not.

• A recent military request for bids for design and development of a celestial body sensor had a preamble in which the contractor was directed to conduct a thorough background investigation to determine the most suitable materials and techniques for use in the sensor. But the fourth sub-specification contained these arbitrary directions: "The associated sensor electronics *shall be completely transistorized.*"

• One large computer manufacturer reported it employs a print-out circuit which is served by a special high-voltage pulse tube. The tube is being used in the company's commercial versions of the circuit; however, military specifications require the use of transistors for this function. The company said its cost is $6.50 more per stage by using transistors and totals several hundred dollars per printer.

• A mammoth military computing system built with transistors has been unable to operate satisfactorily for the past nine months because of transistor failures. Designed for vital defense information data processing, the system has suffered failure after failure and for all practical purposes has been completely inoperable.

• **Wishful thinking?**—In a recent symposium, a well-known designer presented a table of major factors for consideration in the design of transistorized equipment. He compared vacuum tube equipment with what he termed "wishful thinking" in transistor design goals. He cited, for example, that tubes are rated at 300 hours for reliability while transistors have a *goal* of 600 hours.

This same designer compared the maintenance time of the tube and the transistor version. He listed tube replacement time as 50 minutes and transistor replacement time as five minutes. However, he said that in designing the transistor equipment, indicator lights were used to point out which circuits had failed, thus saving much time looking for failure.

While many believe that transistors are just as reliable as tubes, industry observers object strenuously to comparing known facts about tubes with hopeful goals of transistors. To do so, they say, is "blue-sky" propaganda which is unduly and dangerously influencing military defense designs.

G. T. WILLEY . . . management leadership for field testing.

Titan's Testing Time May Be One Half *Atlas'*

SAC personnel to join Martin's streamlined test division in September; static firings may be eliminated at Cape.

by Donald E. Perry

CAPE CANAVERAL—Testing of the Air Force *Titan* should be shortened to one-half of the time required for *Atlas,* and the first SAC crews will be integrated into The Martin Company's Cocoa testing division as test conductors by September, m/r has learned.

The Air Force personnel will arrive during second and third lot testing (B and C series birds) and will include test conductors, lead engineers and technicians for electrical, mechanical, flight controls, missile safety and propulsion.

Static firings at the Cape will be eliminated for *Titan,* which should shorten the time for operational availability by months. Basis for this unprecedented action is the *Titan's* record of performing successfully on its first two flights and the Air Force's conviction that engineering and static tests in Denver are sufficiently advanced to place this much reliability in the missile.

The immediate goal is to fire a *Titan* within one week from its arrival at Patrick AFB via Douglas C-133. Already, the Martin-Cocoa division has chalked up some notable firsts and shown industry that it is neither desirable nor advantageous to regard a testing operation as a stepchild of the parent engineering group. The first test firing on Feb. 6 required a seven-hour countdown. The second firing on Feb. 25 shaved four hours off that time. To top it off, two completely different test crews have fired the bird, and another crew is scheduled to fire the next missile.

• **The man behind it**—The man back of this enviable record is soft-voiced, British-born G. T. (Tom) Willey, senior Martin vice-president and general manager of the Cocoa Division, who continues to speak softly but wields a big management stick with force when he has to.

In October, 1957, Willey established shop at Cocoa Beach and promptly announced he was determined to give real management stature to field testing operations. At that time, there were 100 employees and there was not too much planning to strengthen test schedules for the Big *T* and *Vanguard.* Today there are 945 employees.

Martin's move is being copied by other prime contractors who have since announced full-scale strengthening of testing operations by creating separate management divisions.

The first step was to let a skeleton field force know he was on board. He used the standard industrial engineering approach: housekeeping and cleanliness of the operation—watch the coffee breaks, etc.—which affected employees personally.

• **Tightening up**—After this came a beefing up of the organization with key men transferred from Martin's other divisions. Testing schedules were worked out well in advance and Martin-Cocoa tightened up rules and regulations and refused to take "no" for an answer. The philosophy in effect was to tell the parent plants (Denver, Orlando, Baltimore), that "we can't hold up our testing operations because of you."

At this time, *Vanguard* was requiring about 300 modifications in the field. Willey resolved not to let that happen to *Titan.* "We did not want to become a major modification center for work which could have been done more effectively at the factory," he says. He proved it when it came to flight testing the first *Titan.*

An engine failure during FRF (flight readiness firing) brought one big on-the-spot decision: ship it back to Denver. The division doesn't regret this decision. The vehicle was fired Feb. 25, and required less than 20 field modifications. Further, it backed Willey's theory: a testing operation should work hand-in-hand with the parent group but not be subservient.

While Willey is the first to admit that his division got the benefit of a

COMPLEXITY of *Titan's* ground port equipment is evident as a first s is moved on to Pad 15 at Cape Ca eral for erection.

lot of information from earlier *Vanguard* testing, a Cocoa Division system of coordinating engineering changes necessary in the field with the parent engineering group at Denver has paid dividends.

- **Quick liaison**—A Denver field office was set up at Cocoa to act as a liaison between the Cocoa Division and the Martin-Denver division. When a minor field modification is needed (changing wiring circuits, etc.), the Cocoa Division writes a Liaison Call Sheet (LCS) which says in effect it would be advantageous to the success of the bird presently on the stand if a modification were made as an interim measure.

Without having to await approval from Martin-Denver engineering, the minor mod is made with the concurrence of the Denver field office. Then, Cocoa engineers write a Field Change Authorization (FCA). This is sent to Denver immediately, and if Denver engineering concurs, that group issues a Drawing Change Notice (DCN), listing complete effectivity, thus changing engineering both at Denver and at Cocoa. The FCA takes about a day to jell between the two widely-separated operations.

This system has kept to a minimum the number of modification kits sent from Denver. It has drastically reduced the time for missile checkout. Less than 10 changes—half the number required in the first bird—were made in the second test vehicle fired Feb. 25.

- **Fingers crossed**—*Titan* is a long way from its ultimate goal: capability of eight to 20 servicemen to fire it within 15 minutes. The Cocoa division is keeping its fingers crossed when it enters second-stage testing. But if the division continues to operate the way it has on the first two vehicles, then Martin test people can take just pride.

For Feb. 6 was a milestone date. It was the third-year anniversary of ground breaking for the Denver plant, and it was exactly one year to the day after the Cocoa Division was given first access to the Cape complex area. At that time the area was mostly sand, with only a small amount of concrete poured. Yet in less than nine months, the complex was completed and the ground bird had been erected and checked out.

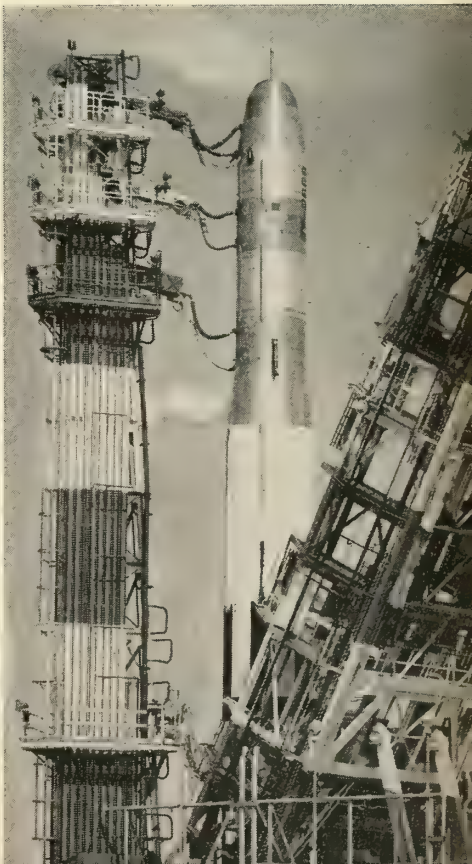
Willey and teams are proud of *Titan's* record but just as proud of the success of *Vanguard II* on Feb. 17. *Vanguard*, first of the big rockets and missiles, had a rougher row to hoe than any of its successors, Willey is quick to point out. Each *Vanguard*, whether it flew or not, contributed valuable information for succeeding missiles and furnished industry with invaluable data, he said.

The next big step for Martin's Cocoa division is to assist ABMA in testing of the *Pershing*, being built by the company's Orlando division. With this missile, the Army will have charge of testing, and undoubtedly new approaches will be demanded. But already, the Cocoa division is preparing for the day with a *Pershing* operations manager on the job. Work is progressing on preparing a test complex at the Cape with site clearing already underway.

Willey's first-string team of directors includes:

R. L. Sansbury, military relations; Kenneth Traut, customer services; William Harwood, information services; C. Q. Butler, procurement, production control and supply; James Holley, industrial relations; F. M. Pilachowski, finance and office services; D. S. Levin, *Titan* operations; R. L. Schlechter, *Vanguard* operations; H. E. Haydon, *Pershing* operations; J. S. Barnitz, programming and contracts; J. S. Krawczyk, quality assurance; W. C. Janda, test services, and E. J. Mommer, *Mace* operations.

TRANSTRAINER vehicle, manufactured by North American Aviation, is used in transporting *Titan* from Denver to Florida on C-133 aircraft and then takes to the road for delivery to pad.



READY for prelaunch checking is test vehicle A-5. The "A" series birds have water-filled second stages but have required a minor number of field modifications after arriving at Cape.

U.S. Surplus Sales Are Rising in Volume

Total of $5.6 billion was sold in Fiscal 1958; efforts made to protect investment and prices.

by E. E. Halmos, Jr.

WASHINGTON—Surplus material with an original value of more than $5.6 billion—ranging from underwear and office machinery to jet airplanes and missile components—was sold by the U.S. government during Fiscal Year 1958.

Average return to the government was about 6% of the original purchase price, meaning that Uncle Sam got back about $336 million of his investment.

Nearly $5 billion of the total surplus sold came from the military departments. And in Fiscal 1959's first quarter, military surplus alone put up for sale totalled about $1.5 billion in original value.

• **Government alert**—There is ample evidence in Washington, according to m/r's careful analysis of the surplus situation, that the government is making every effort to get as much back for Uncle Sam as possible on his original investment—and to prevent adverse effect on markets.

The present system is a great advance over the often chaotic days shortly after World War II, when tons of material of every kind were being indiscriminately dumped, amid endless complications and miles of red tape. Today there is a careful attempt—supervised by two principal agencies—to screen the material turned in as surplus and to market it in locations and in a manner that will not upset prices. Several of the armed services even conduct schools where officers are taught marketing techniques.

• **Terminology first**—Before you talk about "government surplus," you have to understand government terminology. Three terms are the keys: "Personal Property," "Excess" and "Surplus."

"Personal property" means virtually any property that is movable—nearly everything except buildings and land. Airplanes, desks and office machinery, as well as clothing and filing cabinets and rugs, are considered to be personal property.

"Excess" personal property is considered to exist when the head of any major executive agency (such as the Secretary of Defense) decides he doesn't need some equipment or material to further the operations or program of his agency.

"Surplus" doesn't come into being until other agencies of the government have had a chance to look over the "excess" and decide which of it they can use. Whatever is left after this screening becomes "surplus."

There's one more term: "Donation." When all agencies have had a chance to look over "excess" property, the Government's property manager—the General Services Administration—may "donate" some of the surplus to tax-supported or non-profit educational institutions and public health and civil defense organizations. Something like $320 million was donated—including medical supplies and some scientific laboratory equipment—in the 1958 Fiscal Year.

• **What is it?**—At this point, there is very little direct missile material in the mountains of surplus. Not enough missiles of any type have been manufactured to make up much of the pile. But there is a lot of electronic components—most of it part of aircraft and aircraft-handling systems.

In any case, most of the material going up for sale is military hardware and weapons. And the largest share of these weapons is airplanes themselves, which explains the low percentage return to the government on its original investment.

The bulk of the surplus items, then, is outmoded weapons—most of which can be sold only as junk. Another large share of the pile is vehicles. And much of the remainder is working machines—ranging from bulldozers turned in by the Corps of Engineers, to conveyors, materials-handling rigs, and picks and shovels. Worn clothing, damaged items and the like make up the rest.

• **Where is it?**—The size of the military share of surplus is obvious from the figures. In Fiscal 1958 it added up this way: The Army sold material with an original value of $1.5 billion—out of which $925.6 million was sold as scrap, the remaining $592.7 million as still-usable; the Navy sold a total of $1.7 billion worth—$881 million scrap, $802 million usable; the Air Force sold $1.6 billion worth—$1.1 billion scrap, the rest usable.

The process works this way:

In the Department of Defense, when the Army, say, decides that some property is excess, it reports this fact to one of the subordinate organizations under the control of the Assistant Secretary of Defense for Supply and Logistics.

Periodic checks with the other services establish what use, if any, can be made of the Army's excess. If there is none, the list is turned over to the General Services Administration, which sees to it that a similar check is made of all interested government agencies.

If no use is found, the material becomes surplus. If it cannot now be donated, it is put up for sale.

Military sales are then conducted at some 300 military installations around the continental United States.

• **Why is it?**—Government officials contend that bad business practices are only a minor reason for the huge amount of surplus.

In order of importance, they put the reasons for surplus this way: obsolescence; wearing out; standardization of equipment; re-programing. Last—bad purchasing.

About the Cover

This "skin stretching" machine developed by the Cyril Bath Company, Solon, Ohio, is being used for forming alloys of the *Atlas* ICBM, and an electronic control unit allows the metal to be formed with precisions that was previously unheard-of.

The electronic control unit was developed by Assembly Products Systems, the special controls department of Assembly Products, Inc., of Chesterland, Ohio.

The unit receives signals from the Bath load cell and translates them to determine the yield point of the metal to be shaped. Among the design features of the control is the use of locking contact meter-relays as stable reference points for electronic components.

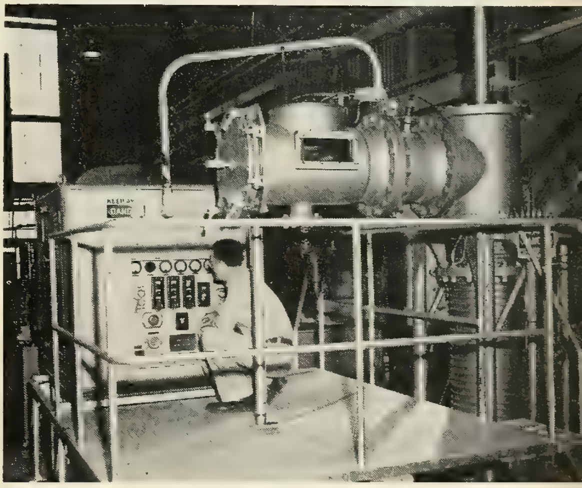
Control signs from electronic units first pass to the meter-relays for checking against values that must be maintained. Then the meter-relays trigger other signals to controlling apparatus that might otherwise tend to hunt and drift.

ASTRONAUTICS in the news . . .

WESTINGHOUSE Research Labs technician uses experimental apparatus to demonstrate solar-thermoelectric power source which will have eventual application on space vehicles.

PITMAN Manufacturing Co. has delivered several of these "high-reach" units for maintenance and servicing of *Jupiter.*

ENGINEER operates Air Reduction Company's new electron beam welder for reactive and high-melting point metals. Controllable 1/16" diameter electron beam bombards materials in a high vacuum chamber.



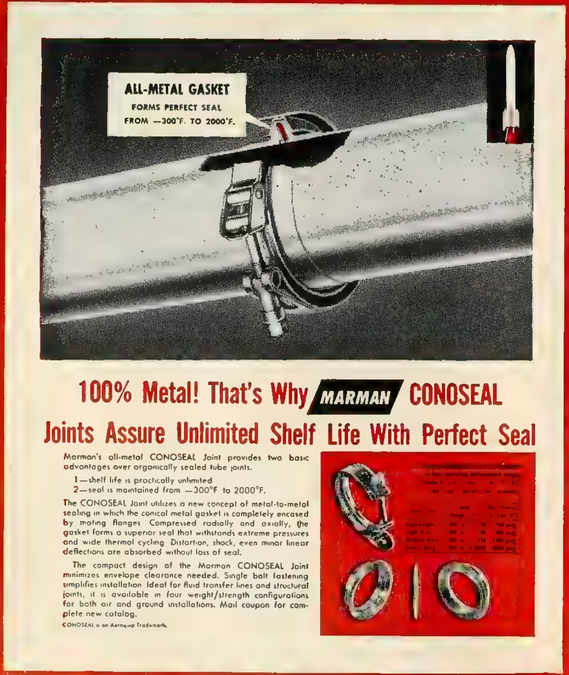
NAVY'S *Weapon Able,* long-range anti-submarine rocket (conventional high explosives) is fired from destroyer.

THIS eight-element spiral antenna at GE Schenectady and a special parametric amplifier permitted 410,000 mile tracking of *Pioneer IV.*

Only the MARMAN CONOSEAL Joint

PROVIDES ALL

THESE ADVANTAGES


ALL-METAL GASKET
FORMS PERFECT SEAL
FROM —300°F. TO 2000°F.

100% Metal! That's Why MARMAN CONOSEAL Joints Assure Unlimited Shelf Life With Perfect Seal

Marman's all-metal CONOSEAL Joint provides two basic advantages over organically sealed tube joints.

1—shelf life is practically unlimited
2—seal is maintained from —300°F to 2000°F.

The CONOSEAL Joint utilizes a new concept of metal-to-metal sealing in which the conical metal gasket is completely encased by mating flanges. Compressed radially and axially, the gasket forms a superior seal that withstands extreme pressures and wide thermal cycling. Distortion, shock, even minor linear deflections are absorbed without loss of seal.

The compact design of the Marman CONOSEAL Joint minimizes envelope clearance needed. Single bolt fastening simplifies installation. Ideal for fluid transfer lines and structural joints, it is available in four weight/strength configurations for both air and ground installations. Mail coupon for complete new catalog.

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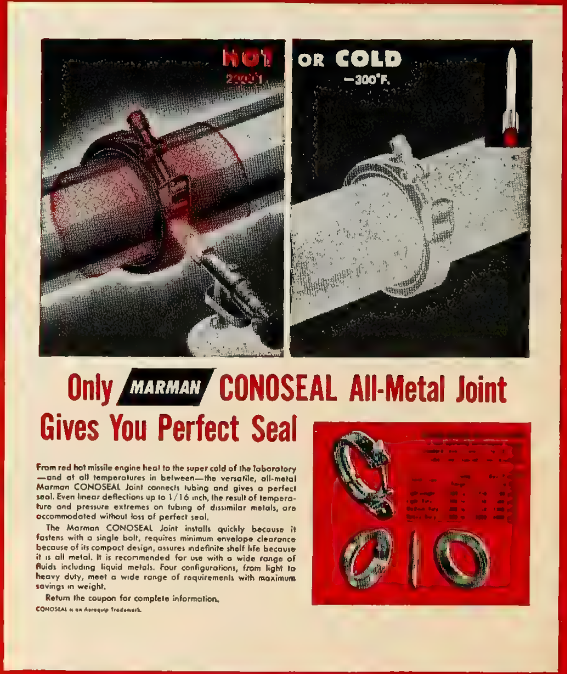
HOT
2000°F.
OR COLD
—300°F.

Only MARMAN CONOSEAL All-Metal Joint Gives You Perfect Seal

From red hot missile engine heat to the super cold of the laboratory—and at all temperatures in between—the versatile, all-metal Marman CONOSEAL Joint connects tubing and gives a perfect seal. Even linear deflections up to 1/16 inch, the result of temperature and pressure extremes on tubing of dissimilar metals, are accommodated without loss of perfect seal.

The Marman CONOSEAL Joint installs quickly because it fastens with a single bolt, requires minimum envelope clearance because of its compact design, assures indefinite shelf life because it is all metal. It is recommended for use with a wide range of fluids including liquid metals. Four configurations, from light to heavy duty, meet a wide range of requirements with maximum savings in weight.

Return the coupon for complete information.

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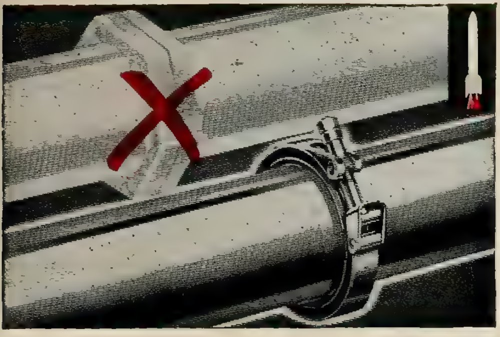


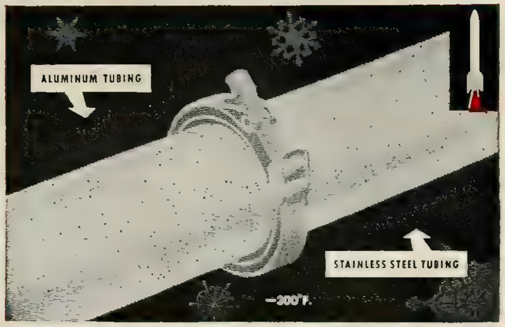
For Quick Connection of High Performance Tubing, Specify MARMAN CONOSEAL Joints

ONE BOLT FASTENS SECURELY

Connect high performance tubing quickly! Get perfect seal! Use the Marman CONOSEAL Joint that tightens with a single bolt—a simple, positive operation even in confined areas.

Important design advantages: The Marman CONOSEAL Joint requires minimum envelope clearance because its diameter is only slightly larger than the tubing it connects. Four configurations, light to heavy duty, provide maximum opportunities for weight savings.

Important operating advantages: The Marman CONOSEAL Joint seals perfectly at extreme temperatures. It joins tubing of dissimilar metals, and accommodates linear deflections up to 1/16 inch resulting from temperature and pressure variations. It has indefinite shelf life because it is all metal; and it may be used for many fluids, including liquid metals. Return the coupon for complete information.



MARMAN CONOSEAL Joints Assure Perfect Seal of Dissimilar Metals at Extreme Low Temperatures

Even at extreme cold of —300° F., tubing of dissimilar metals can be joined in a perfect seal by the all-metal CONOSEAL Joint. Seal is maintained through the full temperature range up to red hot 2000° F. (for applicable tubing). Strength and sealing capabilities are also unaffected by distortion, shock or minor linear deflections.

The Marman CONOSEAL Joint assures unlimited shelf life because it is made entirely of metals not subject to deterioration. Its compact design requires minimum envelope clearance; single bolt fastening simplifies installation. Recommended for a wide range of fluids, including liquid metals, the CONOSEAL Joint is available in four weight/strength configurations. Mail coupon below for complete new catalog.

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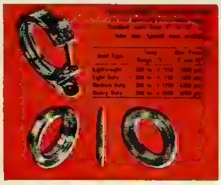
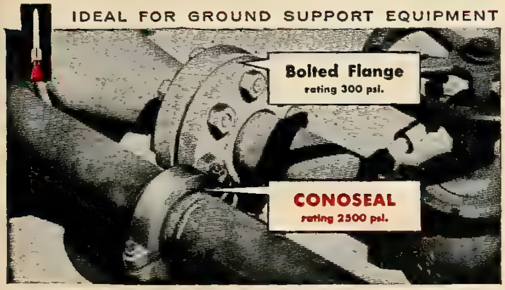


IDEAL FOR GROUND SUPPORT EQUIPMENT

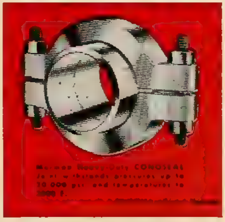


MARMAN Heavy-Duty CONOSEAL JOINT Seals Perfectly at High Temperatures and Pressures

Where extremes of pressure and temperature are standard operating conditions for fluid lines, specify the all-metal Marman Heavy-Duty CONOSEAL Joint. It is designed to provide absolute dependability in connecting and sealing piping, even when subject to severe shock and distortion.

Marman Heavy-Duty CONOSEAL Joints provide maximum insurance against leakage or failure where dissimilar materials must be joined, such as stainless steel to aluminum or Zercaloy. Made entirely of metals not subject to deterioration, CONOSEAL Joints have long shelf life, require no maintenance.

Successfully performing now on jet and rocket engine test stands, high pressure fueling systems, missile test stands and launching platforms, the Heavy-Duty CONOSEAL Joint offers rugged dependability and simplicity of installation to meet a wide range of ground applications. Lightweight configurations of the CONOSEAL Joint are also available for aircraft and missile applications. Mail coupon below for full information.



Marman Heavy-Duty CONOSEAL Joint withstands pressures up to 20,000 psi and temperatures to 2000 F.

Solve high performance tube and pipe joining problems with the versatile Marman all metal CONOSEAL Joint. Four configurations, covering temperature requirements from —300°F. to +2000°F. and pressure requirements from 1200 psig. to 6000 psig., are available for a wide range of missile, ground support equipment, aircraft and other applications. Weight-saving, space-saving Marman CONOSEAL Joints are leakproof, simplify tubing installation, accommodate linear deflections, assure indefinite shelf life. Return the coupon for complete information.

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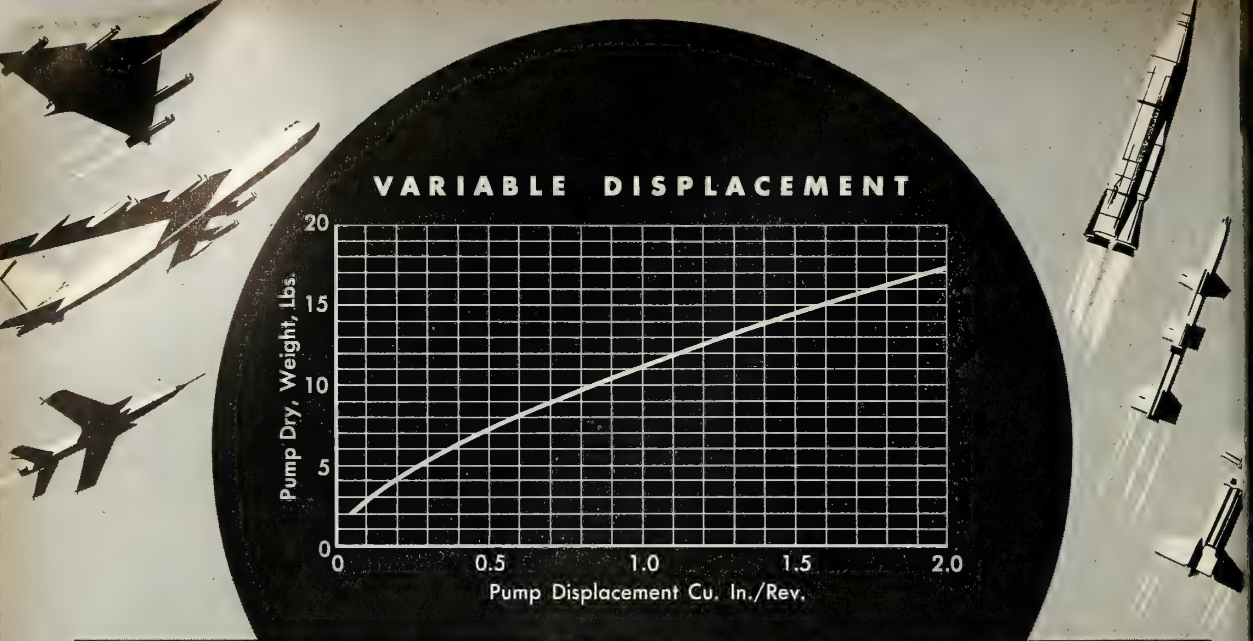
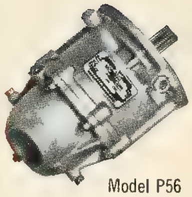
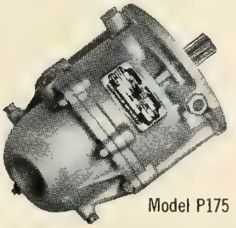


Model	Displacement In 3/Rev	Rated		Max. RPM	Envelope Dimensions	
		RPM	GPM		Diameter	Length
P175	1.750	4000	29.4	5000	5.750	8.320
P105	1.050	4000	17.3	6000	5.250	7.250
P56	.568	6000	13.9	8000	4.687	6.625
P16	.163	12000	7.9	16000	3.000	4.250
P11	.115	12000	5.5	16000	2.750	3.625
P064	.064	12000	3.1	18000	2.125	3.125
P044	.044	12000	2.1	18000	2.125	3.062

A NEW FAMILY OF . . . HYDRAULIC PUMPS WITH THE LOWEST WEIGHT DISPLACEMENT RATIO

For Aircraft, Missiles, and Systems!


Model P56


Model P175

This new family of rotary plunger pumps is furnished with forged aluminum housings for fluid operating temperatures to 400°F. Thousands of hours of endurance and qualification testing, as well as flight tests, have proven that these new pumps will satisfactorily handle all MIL specification hydraulic fluids including Oronite 8515 and will exceed MIL-P-19692 specification requiring 750 hours of endurance. The low weight displacement ratio is accomplished by utilizing space not available in other designs to incorporate the variable displacement feature and servo system. Plungers operate on an inclined axis to provide centrifugal return force and are arranged such that the side loading on each plunger is minimized when the maximum overhung moment occurs.

Fixed displacement pumps are also available in all models with reduced weight and envelope dimensions.

The proven experience of Bendix in manufacturing thousands of direct injection pumps and fuel systems for reciprocating engines, fuel supply pumps, fuel systems for turbine engines, hydraulic pumps, and hydraulic systems for high performance missiles assures you of a quality unit or system meeting the high reliability standards of the industry.

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SPEEDS TO 18,000 RPM

MAJOR PRODUCTS—aircraft and missile hydraulic pumps; hydraulic components and sub-systems; engine fuel pumps and fuel system components; precision bellows and bellows assemblies; thermostats and related sub-assemblies; and sub-contract manufacturing and brazing.

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Simplified Tracking Gear Provides Much Data

Independent Sohio station uses interferometer principle to track satellites—even *Lunik*—and records on two-channel direct-writing oscillograph

by Donald E. Pierce
Brush Instruments
Division of Clevite Corporation

CLEVELAND—Satellite tracking equipment distinguished for its simplicity is providing a wealth of authentic data quickly and accurately at the Standard Oil of Ohio (Sohio) Research Center here.

Two channels of information recorded on a direct-writing Brush Mark II oscillograph can be read directly to determine immediately whether a satellite has gone into orbit. On subsequent passes of the satellite the traces on the oscillographic charts can be interpreted directly to obtain satellite meridian passage time, angular velocity, period of orbit, and rotation modulation.

By utilizing the interferometer principle to track satellites and the two-channel oscillograph to record data, the station is deriving information never before obtained from a single source. Independent of the Minitrack chain of stations, the Sohio station was built as part of Project *Moonbeam,* and is operated as an extra-curricular activity by the scientists on the staff.

Data from a series of passes is correlated to obtain further orbit characteristics and to study the nature of the ionosphere, solar flares and other phenomena. By studying the differences between orbit information obtained theoretically and orbit information interpreted from satellite signals recorded on the oscillographic charts, the research staff has consistently obtained orbit characteristics with a high degree of accuracy.

• **Results obtained rapidly**—Since the station is not part of a chain and does not depend on information from other sources, results can be obtained rapidly. By correlating calculated information and recorded data, Dr. A. L. Jones, head of the research center, was able to predict accurately within a few minutes that *Vanguard II* would not orbit.

Original recordings of *Sputnik III* recorded on the Brush oscillograph are sent periodically by Sohio to the University of Illinois to be used in a joint study of ionosphere density patterns. By sending the original traces Sohio avoids the additional step of duplicating the trace from a magnetic tape recording on which the signals are also recorded.

In transferring a signal there is always the possibility of human error where signals recorded on tape are transferred to oscillographs for study. Errors in correlation with the time signal are frequently encountered in such procedures. With the time signal being recorded directly on the oscillograph chart at the same time the signal is recorded, there can be no error.

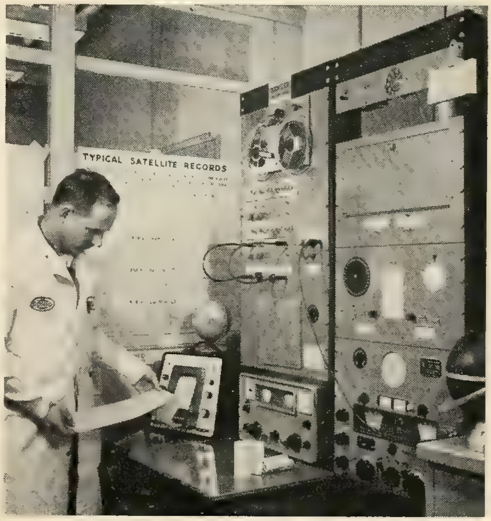
• **Recording signals**—Signals obtained from satellites are recorded to obtain three different types of information. Each requires a different method of analysis.

1. Amplitude—The amplitude of a signal emanating from a satellite as it crosses a lobe pattern is recorded on the direct-writing oscillograph as a series of peaks and nulls. From this single line, information on orbital characteristics can be obtained.

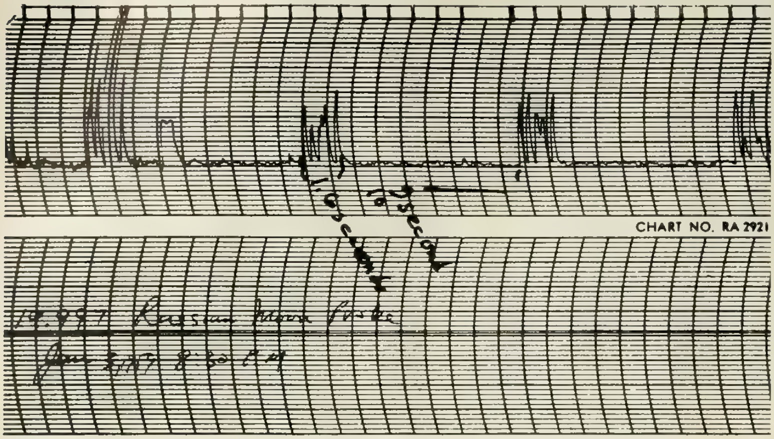
2. Doppler Shift—Frequency shift of a satellite signal as it approaches and recedes rapidly is recorded by passing the signal through a frequency-to-voltage converter and recording it on the direct-writing oscillograph. Doppler shift can be recorded from signals picked up with either the interferometer or a standard dipole antenna.

3. Telemetering—Telemetered information contained in a signal can be decoded by recording the signal on magnetic tape and playing it back through a computer for analysis. Duplicates of tapes made at Sohio are sent to agencies interested in satellite telemetered data. A rare recording of the Russian moonshot signal recorded at the Sohio tracking station was recently sent to the Air Force Research Center for study and analysis.

• **Information varied**—Built to track man-made satellites, the real value of the station's combination of



SOHIO research scientist examines oscillograph trace as satellite 1959 A passes through lobe pattern of Cleveland tracking station.



HERE IS *Lunik's* signal 45 minutes from its closest approach to Moon.

interferometer and oscillographic recorder lies in its function as a radiotelescope. It can intercept radio waves emanating from any signal-transmitting body in space including the sun, radio stars and planetary bodies. Orbit characteristics and velocities of celestial bodies can be obtained from the two channels of information recorded.

Determination of orbital characteristics from single-station observations are made using the satellite's synodic period. A theoretical synodic period is computed and compared with the observed period. From observed angular velocity, which can be read directly from one channel, orbital parameters are obtained.

In addition to orbit characteristics, the Sohio group is obtaining information on solar flares and their effect on the ionosphere and on the magnetic field of the earth.

A very rare phenomenon was recorded at the station during a pass of *Explorer I*. As the satellite was passing through the antenna pattern a solar eruption was simultaneously recorded as a signal superimposed on the satellite signal. The day after this phenomenon was recorded, the area around Cleveland experienced the most beautiful aurora borealis observed in that region in a number of years.

• **Interferometer**—The interferometer measures the distance between nulls corresponding to crossing planes parallel to the meridian. The time between nulls is given by time signals obtained from either WWV in Washington or CHU in Canada. The Brush recorder makes an instantaneous written record of the time signals and satellite radio signals. Each channel of the recorder has two pens, one for recording the time marks and the other for recording satellite data. The data records are accurate to 0.1 seconds.

The Cleveland station can hear satellite launching efforts about four minutes after blast-off and can determine within two hours afterward whether the artificial moon has gone into orbit. The four-minute delay exists since the Cleveland horizon is 125 miles above ground at Cape Canaveral.

• **Receiving system**—The interferometer design of the Cleveland station is a slight variation of the Navy's Minitrack design. The Sohio station is unique as compared to other amateur stations because the Sohio group combines two interferometers on one receiver to resolve ambiguity of the null point at the meridian. The tracking apparatus consists of antennas, a hybrid junction, a converter, a communications receiver, time-marker circuit, direct writing oscillograph and a tape recorder. Band width of the receiver is 500 to 1000 cps.

• **Antennas**—In the original interferometer design suggested by the Navy, two receivers were operated off one antenna 180° out of phase. This design was proposed to eliminate anticipated noise interference. The satellite, however, puts out such a strong signal that this type of setup is not required. Instead, two antennas are connected to one receiver.

Another variation from the Navy design is the use of Yagi antenna arrays instead of dipoles and screen reflectors. Because of the generally low altitude of the satellites at this station and because most American satellites travel south of this station, the Yagi directional antennas are used.

A steerable antenna, the latest addition to the tracking station, is used to pick up signals too weak to be detected by the interferometer.

It can scan the entire horizon in 30 seconds and receive signals 250,000 miles away—20,000 miles beyond the moon.

The interferometer antennas are situated on a true east-west line. The center of the lobe pattern (meridian) is directed to follow the north-south meridian line exactly. This orientation permits accurate detection of the meridian line passage of the satellite.

• **Density variation**—Although the antennas of the interferometer are accurately aligned with the sun, a consistent error of .03 degrees is observed at 108 mc. Error is detected by comparing data recorded at Sohio with data made available from the Naval Research Laboratory. The error is apparently caused by the electronic density of the ionosphere. Study of data obtained over a long period can reveal information on densities, refraction, and variance with many more possibilities existing.

Electronic density variations are part of the study made by the University of Illinois on the ionosphere. In conjunction with this study the Sohio center is sending all data recorded from *Sputnik III* to the university. By studying the data collected from various stations and applying methods of triangulation, the university is carefully calculating density patterns of the ionosphere.

Data Obtained

Successive meridian passage times give more than just the orbit period of a satellite. The interval between passes and the change in interval during a succession of passes are clues to the position of the perigee point and its rate of shift in the orbit plane. The slow pivoting of the orbit plane as a whole about the earth's axis also contributes to this change in interval.

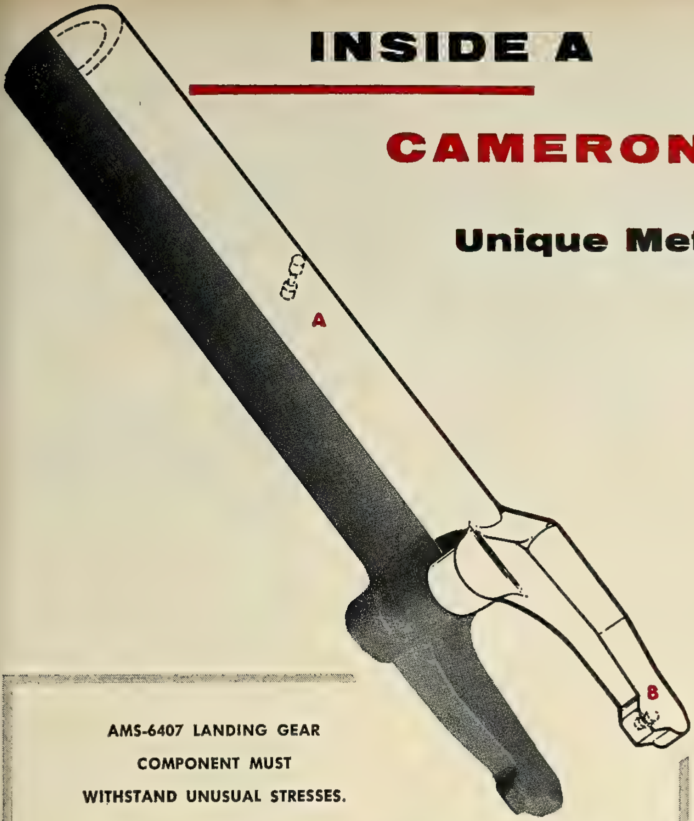
The dimensions of the orbit as well as the linear and angular velocities of the satellite follow from the orbit period and eccentricity. Eventually, it is hoped to combine the peak spacing in the oscillograph trace with a calibration of the antenna to show the inclination of the orbit to the meridian and to the horizontal at each passage.

Meridian passage time—Meridian passage time can be placed to within 0.1 second of passage by locating the center of the lobe pattern as shown on the oscillographic chart.

Period—By referring to the time the satellite passes the meridian on a number of occasions, subtracting the time interval for the rotation of the earth and correcting for other factors, the period for one complete orbit about the earth is accurately established.

INSIDE A CAMERON FORGING

Unique Metallurgical Properties



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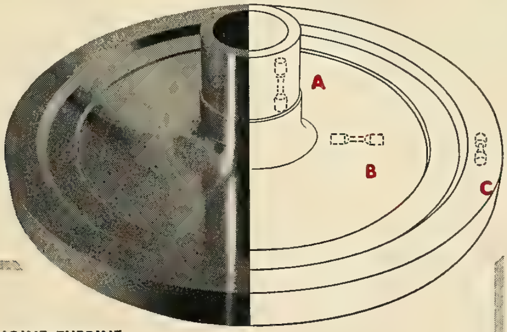
Typical Properties

		Tensile Strength	Yield Strength	Elongation	Reduction of Area Transverse
A	Tube, Transverse	236,000	203,000	12.7%	45.1%
B	Fork, Transverse	233,000	205,000	10.6%	31.9%



A-286 JET ENGINE TURBINE WHEEL OF SPECIAL ALLOY MEETS UNUSUAL DEMANDS.

Typical Properties

		Tensile Strength	Yield Strength .2% Offset	Elongation	Reduction of Area
A	Hub, Longitudinal	158,000	117,000	22.2%	40.0%
B	Web, Radial	159,000	116,000	21.3%	40.0%
C	Rim, Tangential	162,000	117,000	20.3%	39.7%

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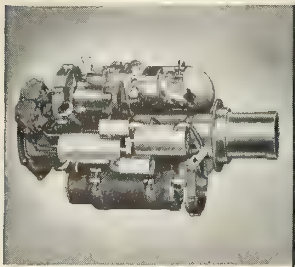
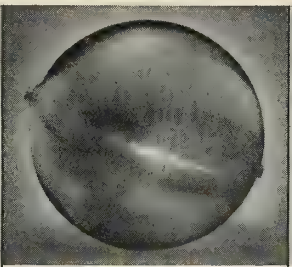
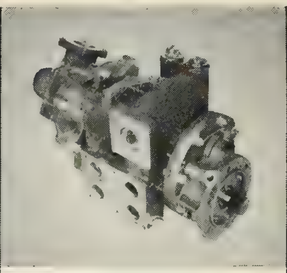
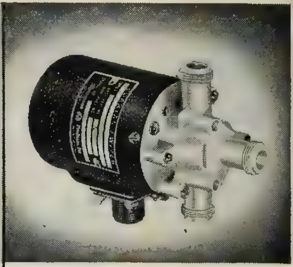
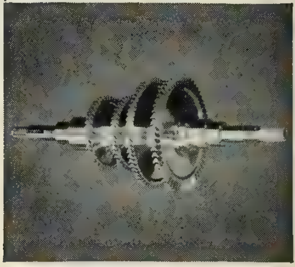

Solid-propellant auxiliary power unit


Titanium missile pressure vessel


Combination main and after-burner fuel pump


Coaxial switch


Four-stage turbine wheel

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APU'S FOR 6 DIFFERENT MISSILES

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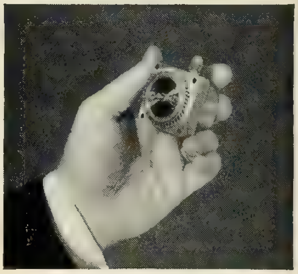
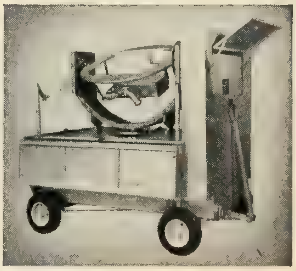
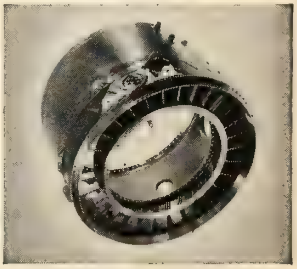
Aircraft and missile technology increasingly demands mechanical systems, equipment, and components that can meet uncommon requirements of precision, strength, and reliability under the most severe environmental conditions. The combination of engineering, metallurgical and manufacturing competence represented in the $160,000,000 per year activities of the Tapco Group provides an integrated capability of unusual effectiveness for the design and manufacture of such products.


100,000 rpm turbine-driven alternator


Missile gyro ground test unit


Jet engine case assembly

TRW **Thompson Ramo Wooldridge Inc.**

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Angular velocity—The satellite's angular velocity through the center of the lobe pattern can be used to derive orbit characteristics when repeated measurements from succcessive passes are available. Angular velocity is read directly from the oscillographic chart.

Rotation modulation frequency—When the symmetry of the satellite antenna pattern is known and subsequent charts are compared, information relating to rotation rate changes is obtained. Dips observed in the charts are caused by rotation of the satellite. The signal frequency is modulated as the satellite rotates and the antennas cycle.

Orbit characteristics—To obtain orbit characteristics comparison is made between observed intervals and calculated intervals between successive meridian passages.

- **Moonrocket signals**—Attesting to the effectiveness of signals recorded at the Sohio tracking station is the record of distinct signals sent out by the Russian moonrocket. The signal was picked up in Cleveland on three different occasions.

The Russian *Lunik* was missed almost completely by tracking stations across the country. Jodrell Bank in Manchester, England, with the largest radio telescope in the world, failed to pick up the rocket's signals.

Signals from the moonshot were picked up, however, at the Sohio station by a 24-foot dipole antenna.

The signal reported by the Cleveland station was confirmed by Air Force intelligence as coinciding with reports on the frequency of the space vehicle's signal. This included number of components in the keyed signal, duration of the signal and time between pulsed transmissions. Pulses had an average duration of 1.6 seconds and occurred every 10 seconds.

The first and third occasions on which the signals were recorded were by reflection from the ionosphere. The other was picked up directly. Duration of the signals recorded was approximately two hours.

Announcement of the moonshot was made at 5:00 PM Friday, January 2. Signals were first picked by Sohio at 7:30 PM the same day and were recorded for two hours. They reappeared at 3:30 AM Saturday and lasted until 5:00 AM. The last time the signal was picked up was from 8 to 9:30 PM Saturday.

Four frequencies were transmitted from the moonshot, 19.993, 19.995, 19.997 and 183.6 mc. The 183.6 mc signal was transmitted from the second stage of the rocket. This stage was dropped before any signal could be picked up on that frequency.

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Paraffin Wax May Be Better for Shielding

Researchers feel hydrogen atoms in wax could absorb more neutrons than plastics

by W. C. Parle and A. M. Erskine

BERKELEY, CALIF.—Sheet lead and paraffin wax in slab form have long been used as shielding materials for absorption of gamma rays and neutrons, respectively. Now the Radiation Laboratory of the University of California, assisted by The California Ink Company, has worked out a new method to combine use of the two materials by uniform dispersion of very finely powdered lead in wax with close tolerances as to density and uniformity of composition.

• **The problem analyzed**—At first it was thought that the lead-wax composition could be manufactured in the form of granules. But consideration of the desired final composition indicated that the problem was actually one of dispersion, analogous in principle to the dispersion of a pigment in a vehicle.

The lead powder, if sufficiently finely divided, would function as a pigment, and the wax in the melted condition would behave as the dispersing medium or vehicle. Because of the wide difference in density between the two components, leading to rapid settling of the lead phase on discontinuing agitation or standing in molds before solidification, it became essential to find some means of appreciably increasing the viscosity of the wax just above its melting point.

It was also desired to manufacture the product in two general forms: one involved pouring the fluid dispersion into containers of various intricate shapes, in which the suspension would solidify on cooling and completely fill the containers with a composition of uniform density; the other form was bricks or large blocks of various sizes having small tolerances in dimensions and readily adaptable to built-up structures.

• **Process development**—There was an extensive laboratory search for additives which in very small amounts would increase the viscosity of the melted wax at a temperature a few degrees above its melting point. This was complicated because the additive could not contain significant quantities of elements which could give undesirable nuclear reactions with gamma radiations or neutrons.

Paraffin-lead shielding will have important use in future space vehicles, particularly for biological shielding and protecting instrument packages against gamma rays and neutrons.

This article by W. C. Parle, technical director of California Ink Company, Inc., Berkeley, Calif., and Dr. A. M. Erskine, the firm's research consultant, discusses a new approach to the combined use of sheet lead and paraffin wax. The material is being used in a portable research reactor at Atomics International, Canoga Park, Calif.

Investigations were also made of types of equipment in which efficient dispersion could be carried out in batches of at least a ton. Other requirements included capability of the dispersion equipment to pour the mixture into molds, close temperature control, etc.

It proved to be relatively easy to manufacture bricks, as well as large blocks, by pouring the suspension into wooden molds, and removing the side walls after solidification.

• **Raw materials**—The lead powder used in this process met rigid specifications of purity and fineness. The purity was controlled basically by requiring that the powder be manufactured from corroding, chemical, or desilvered commercial pig lead. In addition, the maximum permissible percentage of arsenic, antimony or tin was very small (of the order of a few parts per million) and oxygen contamination was kept below a few parts per thousand by weight. The fineness of the lead was specified by a screen analysis, which included at least 30% passing through a 325-mesh screen (44 microns).

REPRESENTATIVE lead wax forms.

The paraffin wax was covered by Federal specifications including a minimum melting point of 160°F. The oxygen specification was the same as that applied to the lead.

• **Physical properties**—The weight ratio of lead to wax (84/16) used in the composition met the specification of a density of 4.0 or 250 lbs./cu. ft. (plus or minus 5%) in the final product. A major problem was to maintain this uniformity of density throughout the large masses which were cast. Obviously, air inclusions had to be prevented completely.

Although gamma ray shielding depends solely on the dense lead present in the mixture, the density of the composition as a whole was brought into a range which permitted relatively easy handling.

Other properties of interest shown by the lead-wax product were: tensile strength 200-250 lbs. per square inch, shear 213 lbs. per square inch, elongation 0.6% and compression 30 lbs. per square inch at 90°F.

• **Shielding effects**—Tests of the lead-wax product for effectiveness in shielding against gamma rays have shown an attenuation coefficient of 0.567 for gamma rays with energy of 1.28 Mev (million electron volts) produced by sodium-22 isotope source. (See S. Glasstone, "Principles of Nuclear Reactor Engineering," page 75, equation 2.60.3). This shielding power may also be expressed as a "mean free path for gamma radiation protection" of 10.2 cm. (4 inches).

Corresponding tests for shielding against neutrons gave an attenuation coefficient of 0.147 for fast neutrons with energy of 2 to 4 Mev from a plutonium-beryllium source. Expressed in terms of "mean free path for fast neutron protection" the value of 10.2 cm.—same as above—was obtained.

Since neutron absorption depends entirely upon the hydrogen atoms in the wax, the use of paraffin wax offers an advantage over plastics, such as polyethylene, because of its higher hydrogen content.

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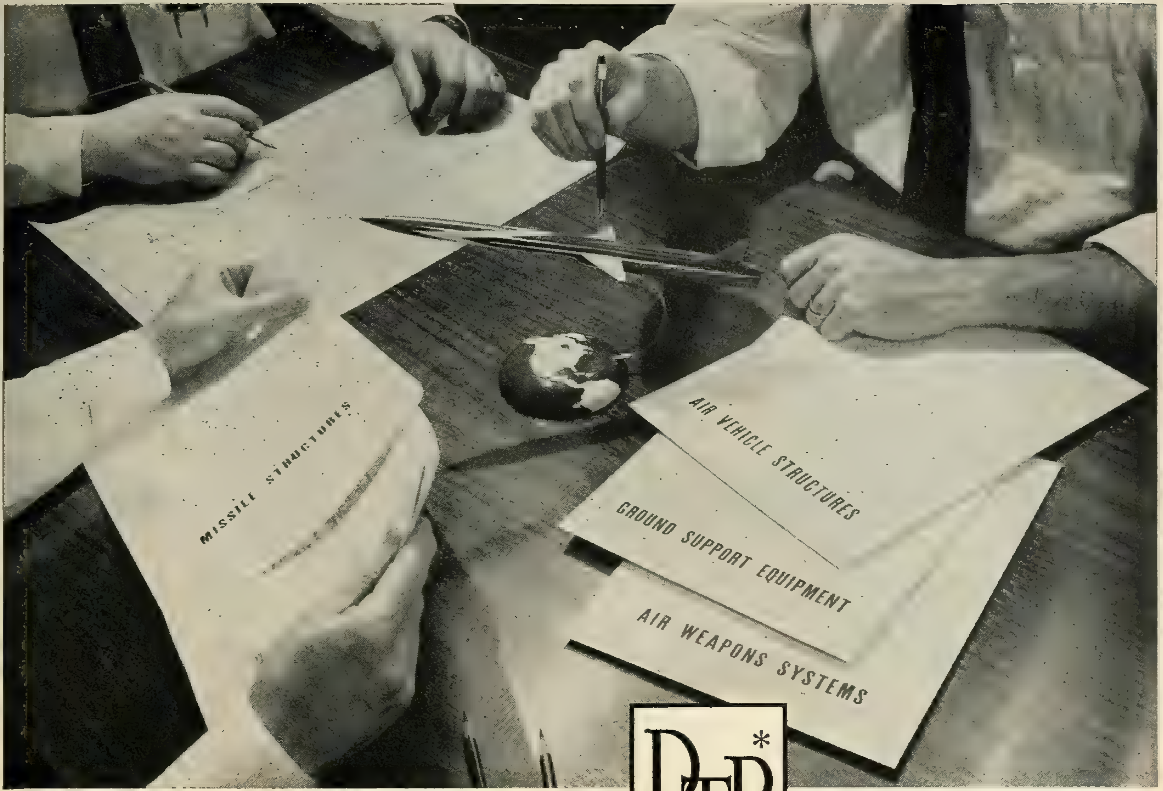

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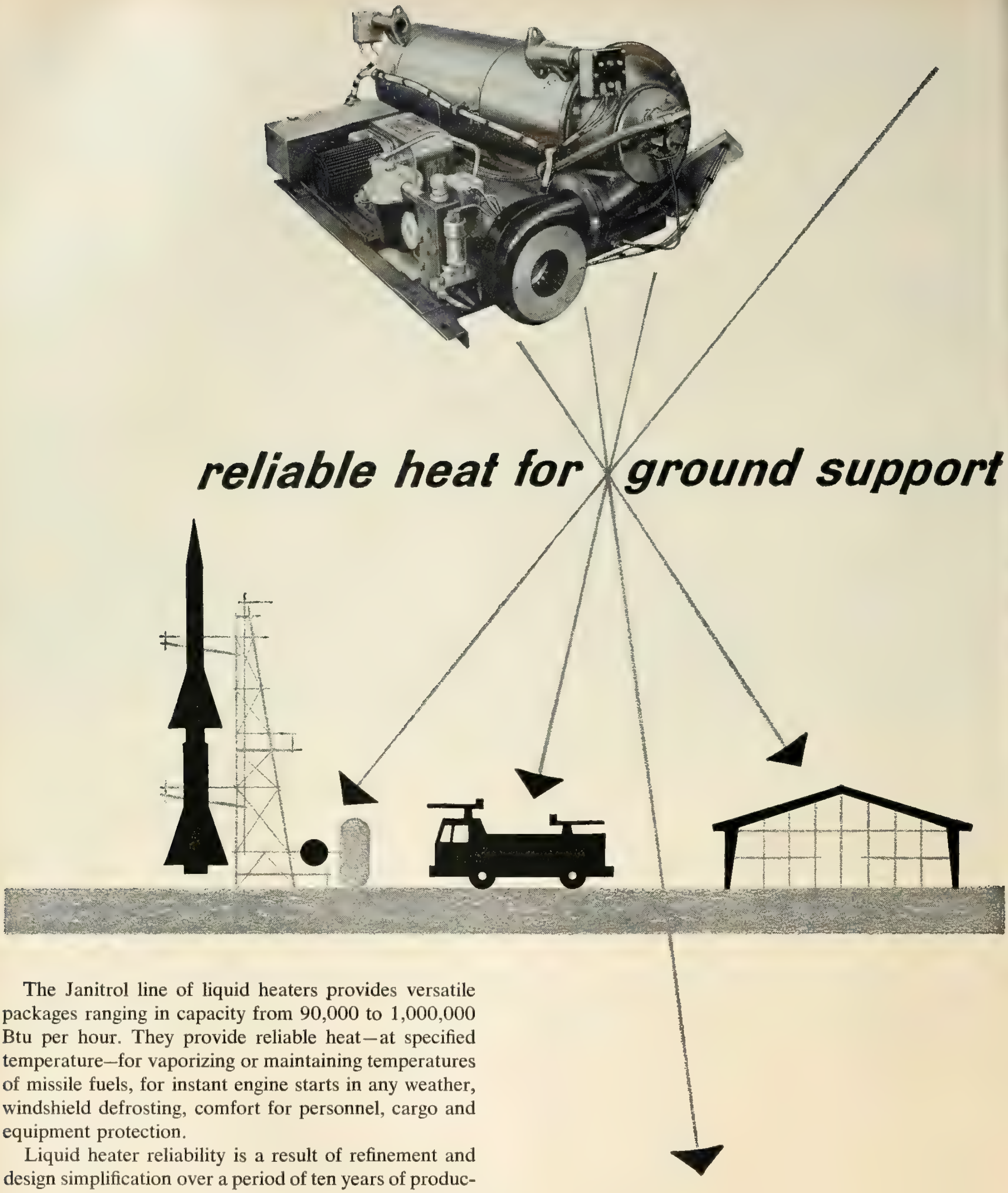
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Spraying Technique May Cut Radome Cost

Gladding, McBean process aims at doing away with precision grinding. Company has tool-up contract for *Sparrow III* radome and sees great potential for future.

by Richard Van Osten

Los Angeles—The high cost of ceramic radomes for missiles may be reduced by a new technique developed by Gladding, McBean & Co., 84-year-old ceramic firm.

First application will be a radome for the *Sparrow III* air-to-air missile. A contract for a tool-up phase has been awarded to GMB by Raytheon, *Sparrow III* prime contractor. Dollar value and number of units to be produced have not been disclosed.

Prime target of the new process was elimination of expensive and time-consuming precision grinding steps, which are suitable for one-of-a-kind or very low production runs, but completely unsuitable for high production.

To meet military specifications on shrinkage, shape, tolerances and electrical uniformity, GMB chose alumina —either 97% or 99% pure, depending upon ultimate use of the radome.

- **Slurry spraying**—First step is the spraying of the high-purity slurry over a special steel mandrel. Mandrel dimensions allow for dimensional tolerances, but the spraying operation is the main key to final success.

The slurry must be sprayed at a pressure high enough for maximum particle packing. It also must be of the proper viscosity to pass through a specially-designed spray gun and atomized to partly dry during buildup.

To accomplish this, alumina is mixed with an organic binder that is soluble in a volatile liquid. The latter remains "tacky" upon contact with the preform and with itself, yet does not soften or deform. The binder is removed during preliminary firing, leaving a final body of either 97% or 99% pure alumina as required.

- **Pressure and firing**—After the slurry has dried on the preform mandrel, the entire assembly is enclosed in a neoprene bag and placed in a reactor where it is subjected to pressure of over 30,000 psi. This achieves a uniform density over the entire radome surface. The radome is then stripped from the mandrel and sent through a preliminary firing at about 2000°F.

- **Machining and firing**—Next step is to machine the radome to the final wall thickness and aerodynamic configuration—with a low-cost process developed by GMB for making joints in sewer pipe!

This machine step allows also for the calculated shrinkage that occurs in final firing. Last phase is the firing in a regenerative kiln at a temperature of over 3000°F.

Much of the procedure is not really new, except to the ceramic industry. Basic development was accomplished under a $215,000 contract from AMC's Aeronautical Systems Center, WADC. Contract calls for two study phases and delivery of other (not *Sparrow III*) radomes to WADC.

- **Great potential**—The process applies to fabrication of other ceramic items of high-purity oxides, and is believed to have much future potential. Time and cost figures are only calculated, but the technique is said to be cheaper than Fiberglas layup methods on a size-for-size, shape-for-shape basis.

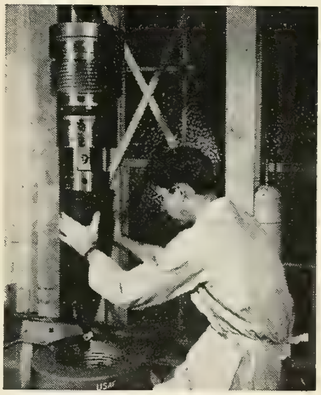
It also offers the ability to mass-produce ceramic radomes with wall thicknesses of 0.05 in. with tolerances of ±0.001 in., an important factor in obtaining constant dielectric characteristics throughout the structure.

- **Varied products**—The Raytheon and WADC contracts mark GMB's first major step into the missile field, although it has produced alumina connector insulators used in missile umbilical cords and in ignition systems subject to high pressure and temperature.

The company has also produced ceramic antenna "windows" for missile and aircraft radar use; ceramic printed circuit boards with a unique plating process; zirconia rocket nozzles; diode holders; solar furnace parts, and ceramic suspension mounts for liquid oxygen containers in liquid propellant engines. GMB is also engaged in classified studies involving nuclear reactor cores and shielding. Certain of these areas involve ceramic laminates in combination with epoxy plastics and foamed ceramic sandwiches.

In R&D studies, sponsored mainly with company funds, GMB has investigated control of electrical characteristics in relation to porosity of ceramics; the use of glass fibers to prestress ceramics; and the addition of metal fibers to increase conductivity.

STEEL MANDREL is sprayed with solution containing 97-99% alumina.



PRESSURE IN reactor assures uniform density over entire surface.

TECHNICIAN PLACES radome in bottom of the kiln preparatory to firing.

AMERICAN AVIATION PUBLICATIONS

ANNOUNCES

airlift

the magazine of world air transportation

Beginning in April, AMERICAN AVIATION Magazine becomes ***airlift***—the monthly magazine serving the world air transportation market. This is not only a change in title but an updating of editorial concept brought about by the evolution within the air age itself. ***airlift*** is edited for the worldwide commercial, military and corporate Air Transportation Industry. Feature articles are designed to interpret trends and developments. They highlight new products and equipment, operations, maintenance, communications, and engineering. ***airlift*** offers editorial coverage of *all* phases of the market concerned with transportation of people and goods by air.

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missile business

by Reed Bundy

Missile and rocket stocks have been pushing the New York stock market to all-time highs recently, with Thiokol Chemical providing much of the impetus. The exchange set successive new records on March 2, 4, 5 and 9. During this period, Thiokol's gains ranged at times as high as 12 points, although profit-taking took some of the wind at times. Other stocks that rang up heavy gains at one stage or another included General Tire, American Potash, Zenith, RCA, Raytheon, Texas Instruments, Litton, I.T.T. and Hoffman.

Some experts called it a "buy now, pay later" push resulting from big contract awards *(Minuteman)* to Thiokol and Aerojet-General (a General Tire subsidiary) and the general lift in missile-space business.

Some of the most spectacular missile-space growth is reported in Florida, where electronics companies alone have 15,000 employees, an annual payroll of $60,000,000 and a gross annual product figured conservatively at $180,000,000, according to the Florida Development Commission. The commission emphasized that these figures do not include Cape Canaveral or Eglin Gulf Test Range—only private manufacturing activity. Its new directory lists some 221 companies "engaged in manufacturing and research related to electronics, aircraft, missiles and scientific instruments."

The Armed Services have reported to Congress that they are stepping up use of incentive contracts to hold down "spiraling costs" of Defense contracts. In separate reports to the Senate Appropriations Committee:

The Air Force said constant requirements for technically superior weapons caused by "competitive technological advances" keep pushing prices higher. It said it is concentrating on incentive-type contracts and such other steps as tighter monitoring of contractors' overhead, closer surveillance of subcontracting activities and research, and greater standardization.

The Army said it was applying similar checks, seeking competitive bids wherever possible and, in missile procurement, using the "breakout" technique. Under this program, as components are developed to the stage where drawings and specifications are available, they are broken out from the prime contract, procured by the government on a competitive basis, and furnished to the subcontractor.

The Navy reported it too was applying closer checks and surveillance and putting greater emphasis on profit incentives. "Implicit in the rewarding of contractors with incentive payments is the assumption of greater risks by them," the Navy said.

Fairchild Engine & Airplane Corp. is closing its Engine Division at Deer Park, L.I., and will sell the plant with the exception of the Gas Turbine and Research Laboratories. J. H. Carmichael, company president, said the move resulted from cancellation of the J83 engine program by the Air Force and because of serious financial losses experienced by the company last year.

Some 160 of the remaining 625 employees at the Engine Division will be retained for a short time.

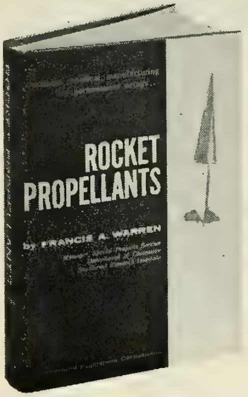
A "tithe for science" bill has been introduced by Rep. Overton Brooks (D-La.), chairman of the House Space Committee. He said the bill will provide that whenever a contract of $10,000 or more for research and scientific investigation is awarded, 10% of the value of the contract shall be set aside for scientific research programs. He said this would give basic research a badly needed shot in the arm.

More acquisitions have been reported as firms move more heavily into missiles and its allied fields. To mention a few: Northrop Corp. is proposing to acquire Page Communications Engineers, Inc., of Washington, D.C., for 95,000 shares of its common stock. The deal is pending before the California Corporations Commission but is expected to be completed in a few more weeks. Meantime, Northrop has approved a $4,000,000 expenditure for a new R&D building for its Nortronics Division . . . Bendix Aviation has entered into an agreement to acquire, for an undisclosed amount, the business and substantially all the property and assets of M. C. Jones Electronics Co., of Bristol, Conn. . . . Turbo Dynamics Corp., of Los Angeles, has acquired 30% of the common stock of National Research Associates, Inc., College Park, Md., and 50% of the common stock of Iresco, Inc., of Santa Monica.

Includes chemical, manufacturing and performance details...

ROCKET PROPELLANTS

by FRANCIS A. WARREN
Manager, Special Projects Section, Department of Chemistry, Southwest Research Institute



1958, 228 pages, $6.50

The purpose of this book is to provide technical men with basic information on the materials being used to propel the rockets and missiles of today, and to recount in an objective manner the fascinating story of rocket fuel development.

It contains the composition, manufacturing methods, and performance details of both solid- and liquid-propellants used in rockets, from small signal units to the largest missiles currently being launched. The book also includes chapters on propellant burning, ignition and igniters, and the various rockets that use each kind of fuel. There is comprehensive information on safety in the propellant manufacturing plant, and quality control of the product.

A final section looks to the future of the present fuels, and reviews the theories that may lead to new ones, such as ion and photon propulsion, and anti-gravity.

CONTENTS: Propellant Systems; Propellant Ingredients; Solid-Propellant Manufacture and Processing; General Performance Characteristics; The Burning of Propellants; Ignition and Igniters; Solid-Propellant Rockets; Liquid-Propellant Rockets; Safety; Evaluation and Quality Control; The Future of Propellants.

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propulsion engineering

Key to cheaper boron fuels: recycle the reactants; end the need to collect, purify, or discard unreacted starting materials. This seems to be the reason Stauffer-Aerojet feels confident its new process will greatly undercut Callery and Olin Mathieson, pricewise. Stauffer-Aerojet will use the new process in its Sacramento, Calif., plant announced in January.

Beryllium fuels will not have Congressional sympathy this year. Some research sponsored by Government agencies will help beryllium pushers, but the biggest aid is not forthcoming—there will be no rapid amortization of equipment needed for development work. A House Ways and Means Committee insider puts it this way: "Fast tax write-offs are out of fashion." Even industries already engaged in proven defense production will find rapid amortization blessings from the 86th Congress very few and far between, he says. Thus, he offers no encouragement to companies ready to invest in equipment and tooling for exotic fuels and materials yet to be proved.

Ozone will be cheaper, more plentiful as soon as a new National Bureau of Standards process goes commercial. The Bureau is almost ready to talk about the process, reveals this much in advance: it goes at a low temperature, the key is a microwave discharge. Bureau of Standards practically never discusses commercial possibilities of its developments, but one scientist says: "The industry boys will be happy with this one."

Demand for oxygen at the turn of the year was steady enough to keep suppliers busy and reassure them on the business success of new plants underway. The Department of Commerce says industrial gases made a good come-back from the early 1958 recession. "Some surplus capacity" is the story in almost every section of the country, but new government projects and an increased steel industry need will swallow this before the year is over. This is why industrial gas leaders can smile when they talk about their new facilities coming on stream this year and early next.

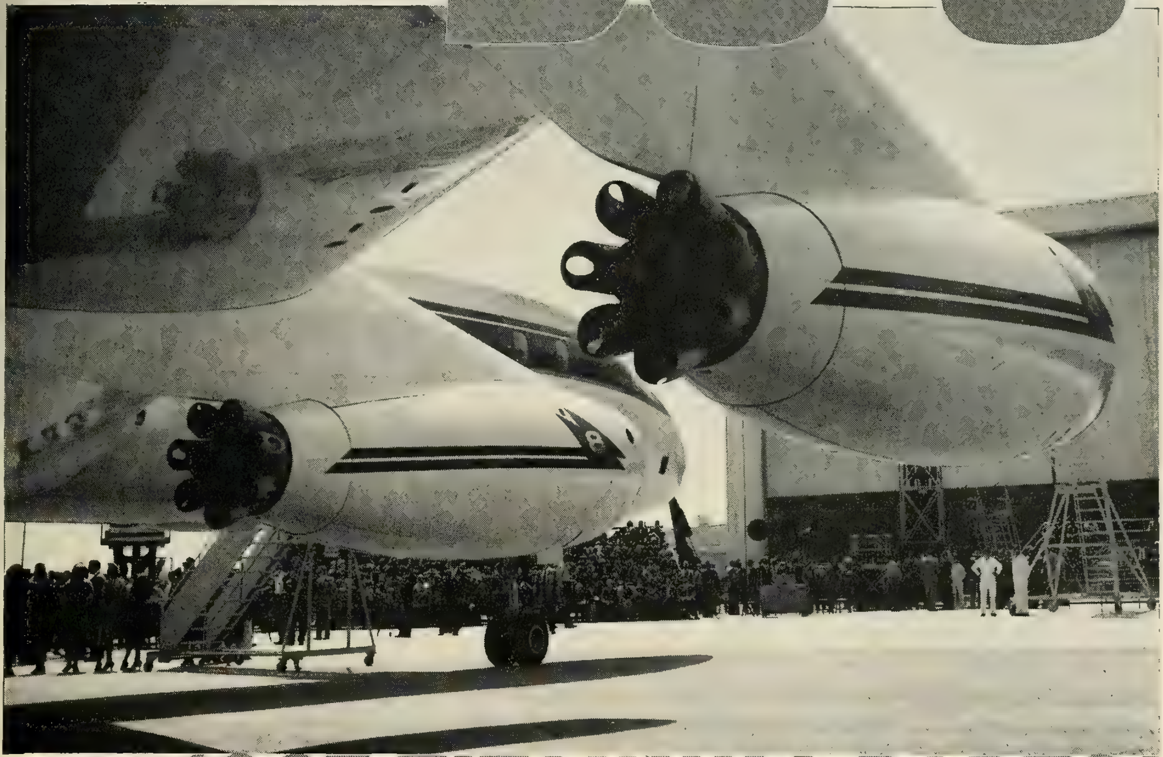
Most talked-about new oxygen plant is Union Carbide's 100 million cubic feet/month facility due early in '60 near Huntsville. Carbide is assuring a bright and long future for its Linde Division operation by looking beyond the government and missiles for its market. Besides missile business around Huntsville, the heavy steel-aircraft-chemical complex between Birmingham and Chattanooga assures Linde a good market, makes steady, high-volume output economical and thus guarantees missilemen a good on-the-scene supply.

A new gelling agent expected to find a use in solid fuels is available from American Cyanamid. Cyanogum-41 converts thin solutions to stiff gels either instantly or at a predetermined later time, depending on the catalyst system and temperature. Add the catalyst just after white Cyanogum-41 powder is added, and many electrolyte solutions immediately take on solid properties. Add the catalyst later, and control the temperature between 26 and 185°F, and the solution gels within 10% of a preset time, up to 24 hours later. Alter the catalyst, the company reports, and the new product will also gel ethylene glycol, glycerine, sulfuric acid and other solutions which to Cyanamid means a "use for Cyanogum-41 in solid fuels."

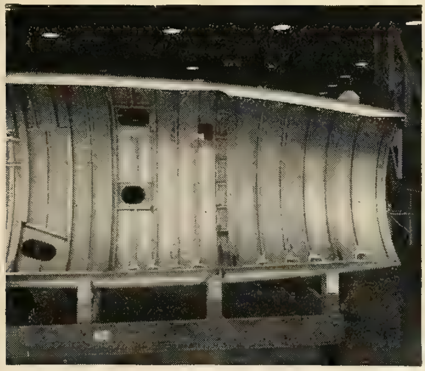
Plastic piping is getting wider use around chemical plants and some missile facilities. Du Pont's Harvey E. Atkinson told the national meeting of the American Institute of Chemical Engineers that polyvinyl chloride (PVC) Type I is working out best for handling corrosives at low and medium temperatures—from 0 to 150°F. He cited cases where PVC is replacing rubber-lined steel pipe for handling acids. An example: $20,000 saved in an operation involving 5000 feet of pipe.

For improved strength / weight in the...

DC-8



1667 TITANIUM PARTS!



***Access door** on DC-8 engine assembly, fabricated entirely of titanium. Skin is .016" thick, ribs and longerons are .032" thick.*

Access doors on engine assemblies, pylon skirts, and hundreds of other structural parts on the Douglas DC-8 are fabricated from high strength, light weight, corrosion resistant titanium.

Mallory-Sharon service engineers have worked closely with Ryan Aeronautical Company engineers—a major supplier of parts and components for the DC-8. New high strength titanium alloys, improved methods of machining and forming, have been developed and employed. The result has been increasingly wide application of titanium's weight-saving advantages—*up to 57%* over stainless steel in many cases.

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A wide selection of the new Bristol stock $\frac{7}{8}$" OD capsular elements is now available in pressure ranges from 15 to 350 psi.

These are the latest of Bristol's long-life, Ni Span C pressure sensing elements widely used in the aircraft and instrument fields. For applications requiring miniaturization, this new $\frac{7}{8}$" OD is the optimum size. Nominal deviations from linearity of these precision miniatures is less than 1%.

Other Bristol stock capsular elements range from $1\frac{5}{32}$" to $2\frac{11}{32}$" OD and have a nominal deviation from linearity of less than $\frac{1}{2}$% (deviation due to hysteresis of less than $\frac{1}{4}$%). Normal operating temperature range is —65° to 300° F. . . . for higher temperatures to (550°) a slight 2% travel change may be expected.

Bristol has been manufacturing pressure sensing elements for 70 years. For further information on these capsular elements with outstanding linearity characteristics write for Bulletin AV2001: Aircraft Components Division, The Bristol Company, 173 Bristol Road, Waterbury 20, Conn. 8.54

BRISTOL FINE PRECISION INSTRUMENTS FOR SEVENTY YEARS

contract awards

AIR FORCE

$85,000,000—**Aerojet-General Corp.,** for R&D on the *Minuteman* program.

$77,000,000—**Thiokol Chemical Corp.,** for R&D on the *Minuteman* program.

$3,678,000—**Sperry Phoenix Co., div. of Sperry Rand Corp.,** for remote guidance and control systems for pilotless jet planes.

$776,625—**Tele-Dynamics, Inc.,** Philadelphia, for telemetric data transmitting sets, major components (black boxes), spare parts, test equipment and data for QF-80 drones.

$568,470—**Lewyt Manufacturing Co.,** Long Island, N.Y., for coordinate data monitor.

$410,371—**United States Steel Corp.,** for stainless steel sandwich rolling program.

$200,000—**Epsco-West,** Anaheim, Calif., Div., for switch timing and monitoring systems for *Atlas* program at Vandenberg AFB (sub-contract from Convair).

$193,839—**Northrop Aircraft, Inc.,** for development and design of improved methods for production of high-strength, lighter weight aluminum and magnesium castings using permanent molds and centrifugal force techniques.

$151,072—**Gilfillan Bros., Inc.,** for modification kits to make spare units compatible with modified radar sets.

$103,951—**New York University,** for studies of electromagnetic theory stressing problems in waveguiding, radiation and diffraction.

$99,193—**Bendix Aviation Corp.,** Pacific Div., for telemetry system used in support of missile test track project WS-133A.

(**Horkey-Moore Associates,** Torrance, Calif., reecived a subcontract from Convair for additional force ejection launchers for *Genie* missiles on F-106 interceptors; **United Control Corp.,** Seattle, was awarded a Convair sub-contract for accelerated engineering and development of equipment to be installed on *Atlas* missiles. Dollar amounts of these awards were not announced.)

ARMY

$2,733,000—**Winger Construction Co., Inc.,** Ottumwa, Iowa, for furnishing and installation of propellant loading system skids at Offutt AFB and Warren AFB.

$2,500,000—**General Instrument Corp.,** Brooklyn, N.Y., for miniaturized air-borne radar "beacons" for target-spotting drones.

$1,010,720—**Western Electric Co., Inc.,** for *Nike* spare parts and components.

$794,285—**Robert J. Genofile, Inc.,** Montrose, Calif., for construction of shops, guard house and weather facility at Vandenberg AFB.

$785,598—**Radio Corporation of America,** for electron tubes (three contracts).

$659,480—**Gordon Fields, Builders,** San Bernardino, Calif., for construction of data acquisition building at Vandenberg AFB.

$402,596—**Sperry Gyroscope Co.,** for additional klystron development models and man-hours of work on broad-banding of high-power C-band klystron amplifiers.

$149,535—**Eitel McCullough, Inc.,** San Carlos, Calif., for electron tubes (two contracts).

NAVY

$51,900,000—**Sperry Gyroscope Co.,** for missile-guidance radars on *Terrier*-equipped ships.

$5,500,000—**National Company, Inc.,** Malden, Mass., for "no drift" radio receivers.

$137,487—**Cutler Metal Products Co.,** Camden, N.J., for shipping containers for major missile section.

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when and where

MARCH

The American Rocket Society, National Capital Section, luncheon sponsored by m/r. Speaker is Richard E. Horner, Assistant Secretary of the Air Force (R&D). National Press Club, Washington, D.C., March 19.

American Society for Metals, 11th Western Exposition and Congress, Pan-Pacific Auditorium and Ambassador Hotel, Los Angeles, March 16-20.

The American Rocket Society, 1959 Sectional Meeting, Daytona Plaza Hotel, Daytona Beach, Fla., March 23-25.

Institute of Radio Engineers, National Convention, Coliseum and Waldorf-Astoria Hotel, New York, March 23-26.

Society of the Plastics Industry, 16th Annual Conference, Pacific Coast Section, Hotel del Coronado, San Diego, March 25-27.

American Society of Mechanical Engineers, Instruments and Regulators Division Conference, Cleveland, March 29-Apr. 2.

Society of Automotive Engineers, National Aeronautic Meeting, Hotel Commodore, New York, March 31-Apr. 3.

APRIL

Conference on Electrically Exploded Wires, sponsored by the Thermal Radiation Laboratory of the Geophysics Research Directorate of the Air Force Cambridge Research Center, Somerset Hotel, Boston, Apr. 2-3.

American Society for Quality Control, Portland Chapter, Oregon Museum of Science and Industry, Portland, Apr. 3-4.

1959 Nuclear Congress, Municipal Auditorium, Cleveland. For information: Engineers Joint Council, 29 West 39th St., New York, Apr. 5-10.

American Welding Society, 1959 Welding Show and 40th Annual Convention, International Amphitheatre and Hotel Sherman, Chicago, Apr. 7-10.

Air Force Association, World Congress of Flight, Las Vegas, Nev., Apr. 12-19.

Aeronautical Training Society, 17th Annual Meeting, Las Vegas, Apr. 16-17.

American Society of Tool Engineers, Annual Meeting, Schroeder Hotel, Milwaukee, Apr. 18-22.

American Rocket Society, Man-in-Space Conference, Hotel Chamberlain, Hampton, Va., Apri. 20-22.

Institute of Radio Engineers, Spring Technical Conference on Electronic Data Processing, Cincinnati Section, Engineering Society Bldg., Cincinnati, Apr. 21-22.

Institute of Environmental Engineers, 1959 Annual Meeting, La Salle Hotel, Chicago, Apr. 22-24.

American Rocket Society, Controllable Satellite Conference, Massachusetts Institute of Technology, Cambridge, Apr. 30-May 1.

MAY

Institute of Radio Engineers, 11th National Aeronautical Electronics Conference, Dayton, Ohio, May 4-6.

Instrument Society of America, 5th National Instrumentation Flight Test Symposium, Seattle, May 4-7.

International Scientific Radio Union, Spring Meeting, Willard Hotel, Washington, D.C., May 5-7.

1959 Electronic Components Conference, Benjamin Franklin Hotel, Philadelphia, May 6-8.

Aviation Writers Association, 21st Annual Meeting and News Conference, Washington and Willard Hotels, Washington, D.C., May 10-16.

Armed Forces Day, Observances scheduled throughout week of May 9-17.

The Society for Experimental Stress Analysis, 1959 National Spring Meeting, Sheraton Park Hotel, Washington, D.C., May 20-22.

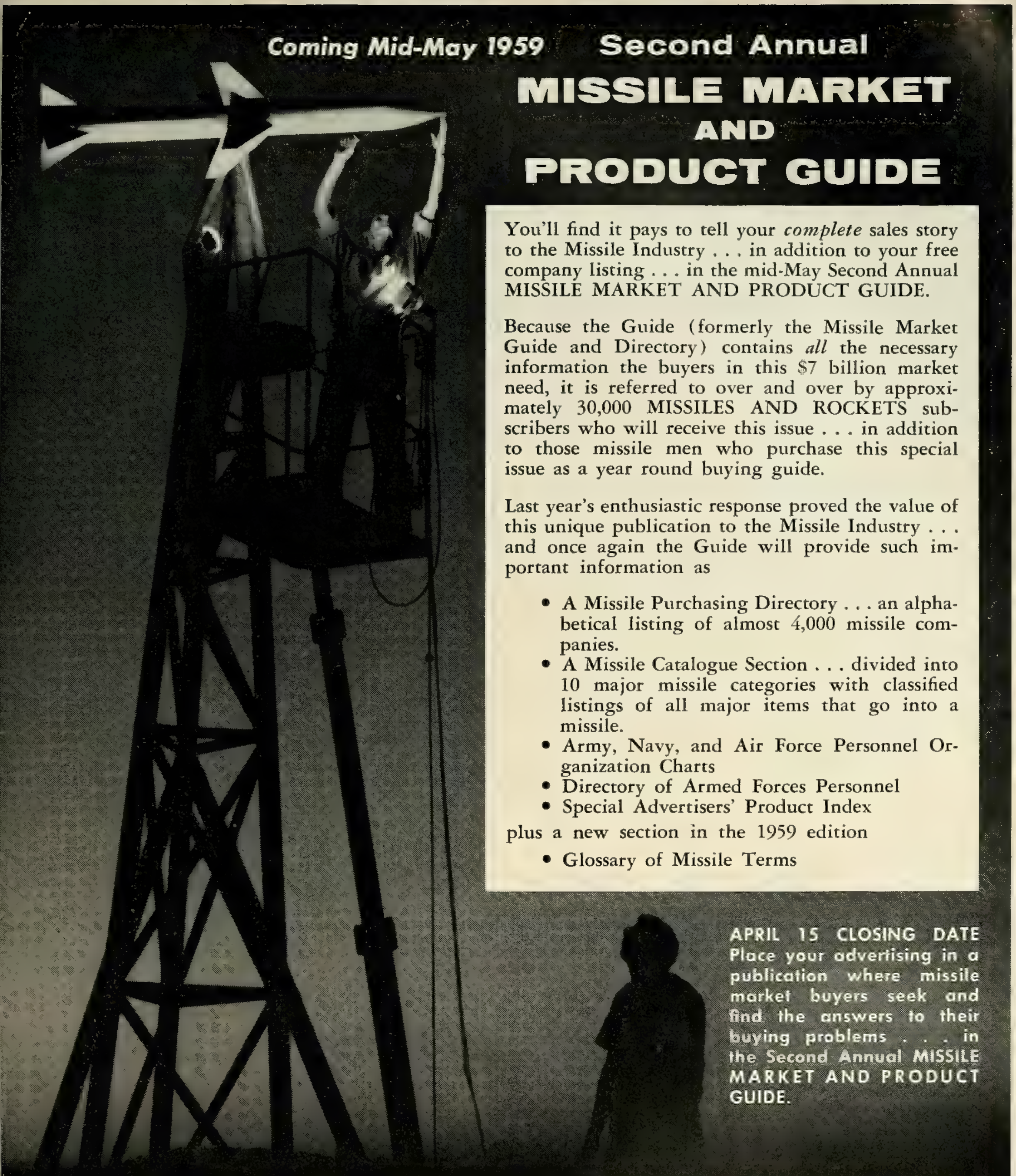
Institution of Electrical Engineers, The Radio and Telecommunication Section, Earl's Court, London, England, May 21-27.

American Rocket Society, Institute of the Aeronautical Sciences, American Institute of Electrical Engineers and the Instrument Society of America, Brown Palace and Cosmopolitan Hotel, Denver, May 25-27.

Federation Aeronautique Internationale, Annual Conference, Moscow, May 28-31.

JUNE

American Rocket Society, Semiannual Meeting, San Diego, June 8-11.



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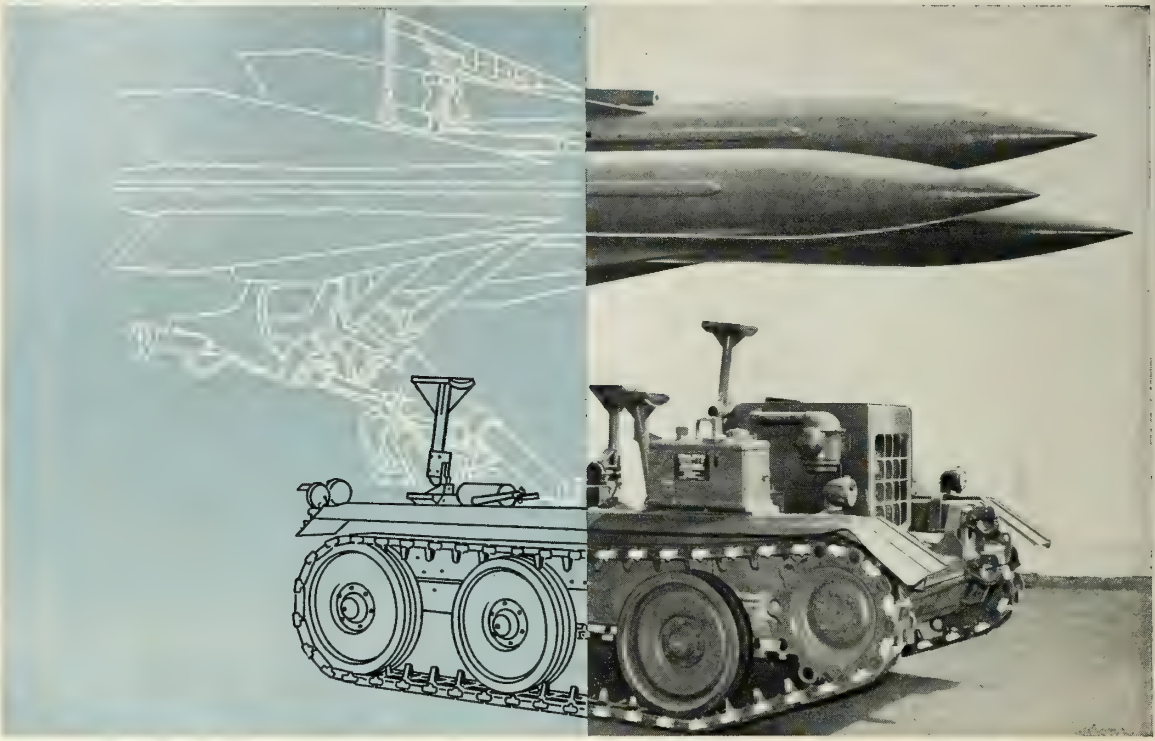

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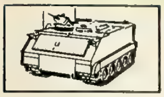

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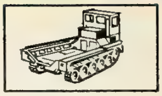

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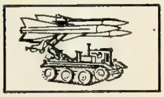

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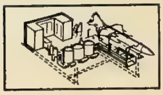

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Here is AOMC's *Jupiter* Contract Breakdown

WASHINGTON—More than two-hundred contractors had a part in producing the modified *Jupiter* IRBM used to send *Pioneer IV* into orbit around the sun.

According to a fact sheet released by the Army Ordnance Missile Command at Redstone Arsenal, Chrysler, the prime *Jupiter* contractor, furnished engineering services and some hardware, although the booster was fabricated by ABMA at Huntsville.

Major *Jupiter* subcontractors are Ford Instrument Co., guidance and control; and Rocketdyne Div., North American Aviation, propulsion. For this project, Reynolds Metals Co. built the shell of the rotational launcher.

Other contractors:

Adel Precision Products Corp., check values for high pressure air supply, air bearing system and fuel system; Aeronutronic Systems Inc., research on high precision orbit determination; AFR Products, Inc., meter and tuning unit; Aircraft Porous Media Co., filter for hydraulic control system in rocket engine; filter for cooling system; Airesearch Mfg., absolute pressure regulator, in instrument compartment; Allen Mfg. Co., cap screw for rotational launcher assembly; Alto Scientific Co., tuner; American Lava Corp., heater core for air bearing system.

Ampex Corp., recorder and magnetic tape recorders for testing booster components and overall missile flight checkout; Anadite, Inc., conduit, fuel and vent pipes; Apor Heating Corp., thermostats for temperature control coding system; Armstrong Products Co., cement for destructor and adapter assembly; Baldwin-Lima-Hamilton Corp., measuring systems for loads, cells and thrust in testing operations; Beckman Instruments, Inc., frequency meter; Beckman and Whitley, Inc., arming unit in destructor and adapter assembly.

Bendix Aviation Corp., Los Angeles, gas reaction controller; Bendix Aviation Corp., Detroit, reaction controller and rotation machinery; Bendix Filter Division, Madison Heights, Mich., hydraulic filters for control actuators; Bendix Aviation Corp., Utica, N.Y., high pressure spheres, fiberglass containers for pressurizing systems; Benson Mfg. Co., fuel suction connector; Benton Valve Corp., valves for hydraulic and measuring systems; Bomac Labs, Inc., magnetron tube; Bomar Instrument Co., speed changer; Bournes Laboratories, Inc., variable precision resistors used in several electronics systems; D. S. Brown Rubber Co., rubber connection and seals for cluster assembly; Brown Engineering Co., bolts for large access door on aft section; tilt frames for guidance system.

Brush Electronics Co., oscillographs used to record results of flight dynamics study; Burroughs Corporation, computers used in developing data in several ABMA laboratories; Byron-Jackson Tools, Inc., cryogenic pumps, valves and trailers used in testing operation; Cadillac-Gage, air pendulum to level gyro stabilizer platform; Cambridge Corp., cryogenic tanks, pumps, valves and trailers used in testing; Camloc Fastener Corp., structural quarter-turn fasteners for access doors in aft section; Cannon Electric Co., plug for rocket engine modification; J. C. Carter Co., cryogenic pumps, valves and trailers for testing operations; Century Electronics & Instruments, Inc., pressure switches for propulsion system measurements and controls.

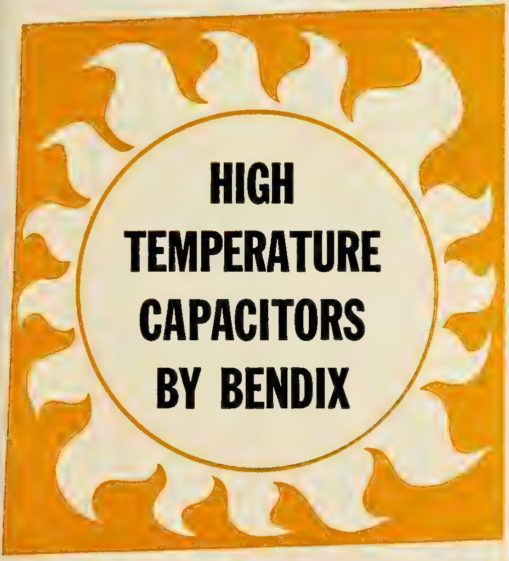
Cincinnati Testing and Research Laboratory, sealer for shroud coating; Cherry Burrell Corp., container tests for propulsion system; Chicago Pneumatic Tool Co., high pressure compressors; Chromalax, Inc., heating blanket; Chrysler Corp. Missile Division, quick-disconnect couplings for fuel and liquid oxygen systems; cables and valves in aft and tail sections; Chrysler Corp. Airtemp Division, air-conditioning; C. P. Clare and Co., selector switch to coordinate resolver computer in guidance and control system; Clevite Corp., recorder, oscillograph, and amplifier; Component Parts Co., check valve for fueling system; Communication Measurement Lab, frequency converter.

Consolidated Electrodynamics Corp., millisadic, recording oscillographs, transducers, oscillogram processors, D.C. power supplies, used for testing components and overall missile flight checkout; Cornelius Co., safety valves for air bearing system; Crane Co., cryogenic pumps, valves and trailers; high pressure valves and pipe fittings for testing operations; Cyril Bath, ring, channel and "Z" frames for support of missile's outer shell; Daven Co., attenuator; De Mornay Bonardi Corp., waveguide, mount, coupler, tee, mixer tunes, shorts, flange, stand and screws; Dow Chemical Co., insulators for tail and aft section; E. E. du Pont Co., booster and actuator used in missile's destruction apparatus; D. S. D. Manufacturing Co., toruseals for liquid oxygen system.

Eagle-Picher, batteries for power supply; Eastern Air Devices, Inc., alternator for spin launcher, a component of cluster speed control system; Edcliff Instrument Co., angle-of-attack instrument for control system; Elastic Stopnut Corp., machine nuts for LOX and fuel systems; floating anchor nuts for rotational launcher assembly and instrument compartment; Electro Data Division of Burroughs Corp., digital computers used for stability accuracy determination and analysis of flight dynamics of missile; Electromation Co., micro-miniaturization program device; Elgin National Watch Co., relay; Ensign-Brickford Co., prima cord for destructor and adaptor assembly and for separation of nose and aft sections.

Fairchild Control, potentiometers for velocity computer in guidance system; Fansteel Metalurgical Corp., rectifiers and capacitors for guidance system; Firestone Co. (West Coast Division), radio beacon for tracking of missile; air-bearing gyro for stabilized platform in guidance system; Fenwal Electronics, Inc., thermistor type temperature gages for guidance system; thermostats for air bearing system; Flexonics Corp., flexible hoses in instrument compartment; hoses for hydraulic, air and liquid oxygen in tail section; Flexitallic Gasket Co., toruseals for liquid oxygen and fuel systems; Ford Instrument Co., regulating system, program device and velocity computer in guidance and control assembly; Friden, Inc., transmitter-receiver; Fruehauf Trailer, 5,000-gallon trailer for fuel trans-

(Continued on page 48)



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fer; Futurecraft Valve Corp., valves, rings and plugs for fuel system.

Garlock Packing Co., grease and air pressure seals for rotational launcher assembly; U.S. Gauge Co., manifold pressure gage for main valve box; General Electric Computer Center, operates part of Computation Laboratory, ABMA, where general development and trajectory computations were accomplished; General Electric, transistors and semiconductors for telemetry, transmitter and data equipment; GE, Fort Wayne, Ind., DC motor for spin launcher; General Motors Corp. (New Departure Division), ball bearings for rotational launcher assembly; General Radio Co., miscellaneous electronic components; G. M. Giannina and Co., pressure transducer to measure propulsion system pressures; accelerometers to measure longitudinal acceleration of the missile; Gilfillian Brothers, Inc., radio beacon for tracking of missile for flight instrumentation; Globe Industries, timer, DC motor and gear box assemblies used in upper stages of missile; electro-mechanical actuators for spatial attitude control system; Greer Hydraulic, Inc., hydraulic accumulators for *Jupiter* hydraulic system.

Handley Electronics Inc., variable precision resistors used in electronic control systems; Hammel-Dahl, high pressure valves and fittings used in testing operations; Hayes Aircraft Corp., flame shields used to protect booster and components; Heath Corp., Heathkits for flight simulation studies; Helipot Corp., potentiometers for velocity computer in guidance system; Heli Coil Corp., threaded inserts used at missile handling points; Tom Henkel, ring frames for support of outside skin; Henry Vogt Machine Co., Inc., high pressure valves and pipe fittings used in testing; Hufford Corp., knuckle, ring, channel and "Z" segments used to support outside skin and tank construction; Herrick L. Johnston, Inc., cryogenic tanks, pumps, valves and trailers; Hewlett Packard Co., counter and recorder, voltmeter and oscillator; Hoffman Electronics Corp., Evanston, Ill., transistors and semiconductors for missile attitude measuring adapters; Huck Mfg. Co., bolts and blind rivets for shroud and aft section assembly; Humphrey, Inc., potentiometers for *Jupiter* engine gimbal actuators; Hydraulic Research, servo valve for rocket engine modification; Hydromatics, Inc., liquid oxygen replenishing vent for transfer system; valve for cooling system in instrument compartment.

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Linde Air Products Co., liquid oxygen and nitrogen; Leeds and Northrop Co., electronic strip-chart recorders used in testing; W. O. Leonard, Inc., regulators air flow; Lockheed Aircraft Corp., camera equipment; Lord Mfg. Co., shock mount in instrument compartment cooling system; Marotta Valve Corp., solenoid valve used in control of air flow; valves for propulsion system and instrument compartment; Magnetic Research Corp., magnetic amplifier for temperature measurements; Marman Products Co., Inc., clamps used in liquid oxygen and fuel systems, instrument compartment cooling system; Mark's Oxygen Co., Inc., liquid oxygen.

Melpar, Inc., transponder used in missile-borne radar tracking beacon; Metron Instrument Co., contractor for rotational launcher assembly; Micro Switch, limit switches for spatial attitude control system; Microswitch Division of Minneapolis-Honeywell, microswitch used in fuel transfer system; Microwave Associates, Inc., varactor diode; Midland Mfg. Co., frequency control components for tracking station built by ABMA; Minnesota Mining and Manufacturing, sealer coating for shroud; sealing compounds and insulation tape for aft section; Minneapolis-Honeywell, transistors for attitude measuring and control; Minneapolis-Honeywell Regulator Co., electronic recorder; Mooga Valve Co., Inc., linear actuators and valves for guidance and control system; Modern Industrial Plastics, seals and gaskets for liquid oxygen, hydraulic and oil system.

Motorola, Inc., telemeter antennae; flowmeter adapter for propulsion system; McKay Tool and Engineering Co., explosive bolts for nose cone separation; Neptune Meter Co., flow meter and seal for fuel transfer system; New York Air Brake, hydraulic pumps in several areas of missile and ground support equipment; Noble Norman, actuator and nozzle assembly for spatial control system; Norda Microwave, attenuator; North American Aviation, regulator and coupling on liquid oxygen and spatial attitude control systems; Omega Labs, Inc., termination and waveguide attenuator; On-Mark Couplings, couplings for fuel system.

R. H. Osbrink Mfg. Co., missile antennae; Owens-Corning Co., fiberglass for rocket engine modifications; Parker Aircraft Co., check valves for hydraulic system; Parker Appliance Co., restrictor check for hydraulic control system; reducers and elbows for pneumatic systems; Parker Hannifin Corp., fittings for liquid oxygen, fuel and pneumatic systems; Philbrick Corp., amplifiers for guidance and control; Philco Corp., transistors and semiconductors for telemetry, transmitter and data equipment; Perkin-Elmer Corps., vernistats used in analog computer simulation of missile flight dynamics.

Permanent Filter Corp., filter for high pressure air supply; PIC Design Corp., gears used in coordinate resolver computer; Polytechnic Research and Development Co., amplifier, bridge, generator, meter, and crystal mount waveguide; Potter Aeronautical Corp., flowmeters for liquid oxygen and fuel; Potter Aeronautical Corp., frequency converter; William Powell Co., pumps and valves for testing; Precision Equipment Co., check valves for instrument compartment cooling system; Precision Rubber Products, gaskets for engine modification; Protective Closures, Inc., caps and plugs for fuel system; Purolator Products Co., oil hydraulic fluid filters; Quester Corp., endless hose.

Raytheon Mfg. Co., transistors and semiconductors for telemetry and transmitter equipment; Radio Engineering Labs, Inc., receiver; Resdel Engineering Corp., receiver set; Resistoflex Corp., flexible hoses for hydraulic, liquid oxygen, fuel and pneumatic systems; Reynolds Industries, antenna mount and telemetering in nose section; Robinson Aviation Inc., shock mount vibration isolators to measure propulsion system pressures; Rosan, Inc., threaded inserts for rotational launcher assembly; Ronan & Kunzl, Inc., liquid oxygen/nitrogen container; Arthur C. Ruge Associates, Inc., resistance type temperature gages for temperature measurement; Scientific-Atlanta, Inc., pattern platter; Simons Fastener Corp., quick fastener for instrument compartment; Servo-Mechanism, Inc., computer (liquid oxygen level indicator); A. O. Smith Corp., high pressure vessels for testing operation.

Southwestern Industries, pressure switches to regulate fuel tank pressure; valves for fuel and air systems; Southwest Products Co., bearings for booster roll control; Spectrol Electronics of Carrier Corp., potentiometers for spatial control system; Spincraft, Inc., bulkhead for tank section; Spitz Laboratories, Inc., lunar flight trajectory models; Stathem Laboratories, accelerometers for attitude measuring control; Systems, Inc., antenna; Technical Appliance Corp., antenna; Texas Instruments, Inc., transistors and semiconductors for telemetry and guidance and control equipment.

Thiokol Chemical Corp., small rocket motors for booster; Thermo Form, bulkhead, component of tank assembly; H. I. Thompson Co., fiberglass flame shields and insulators in tail section; Transistron, transistors and semiconductors for telemeetry and transmitter equipment; Tube Turns, Inc., high pressure valves and pipe fittings for testing of booster; Turbocraft Co., cryogenic pumps, valves and trailers for testing operations; United States Rubber Co., drive belts for rotational launcher; U.S. Steel Corp., high pressure vessels for testing operations; United Transformer Co., transformers and inductors for guidance and control system; University of Illinois, study of radiometric missile tracking; Utility Metals Products, rings, doors and door frames for booster.

Varian Associates, Inc., Klystron; Vulcan Trailer Mfg. Co., modification of semitrailer; Wallace Barnes Co., springs to modify valves and other components; Walter Kidde Co., filter for instrument compartment cooling system and high pressure air supply; Wallace O. Leonard, regulator for air bearing system; Weinschel Engineering Co., termination attenuator and tunes; W. M. Whittaker Co., air flow control valve; Wiancko Engineering Co., transducer mounts to measure propulsion system pressures; E. B. Wiggins Oil Tool Co., Inc., quick disconnect apparatus and couplings for hydraulic, liquid oxygen and fuel systems; Franklin C. Wolf Co., Inc., seals and gaskets for aft section assembly; Zenith Radio Corp., receiver for command-destruction signal.

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Boeing List Shows 35 Major Suppliers

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Aerojet-General Corp., boost rocket motors; American Gyro Division, rate gyros; American Machine & Foundry Co., weapon support equipment; Armco, 17-7PH steel; Bendix Aviation Corp. instrumentation beacon and inverter.

Bill Jack Scientific Instrument Co., motors; Brunswick-Balke-Collender Co., radomes; Blount Brothers Construction Co., weapon support equipment; Burns & Roe, Inc., ground support equipment; Cadillac Gage Co., servo valves; Cushing & Nevell, illustrated parts breakdown; Dalmo-Victor, drive assemblies.

Farnsworth Electronics Co., operation test equipment and electrical launching equipment; Federal Telephone & Radio Co., GAT amplifiers; Food Machinery & Chemical, weapon support equipment; Foote Brothers Gear and Machine, gear boxes; Kaiser Metal Products, Inc., fuel tanks; Leer, Inc., coordinate converter and data link receiver.

Librascope, Inc., transformer-rectifier; Minneapolis-Honeywell Regulator Co., weapon support equipment; Moogl Valve Co., Inc., valves; Motorola, Inc., guidance beacon and data link decoder; Radio Corporation of America, radar; Southgate Aluminum and Magnesium Co., chassis assemblies.

Stewart-Warner Corp., cooling assembly; Taylor Forge & Pipe Works, forgings; Telechrome Mfg. Co., transmitters; Texas Instruments, Inc., telemeter; Thompson Products, Inc., switches; United Control Corp., switches.

Varian Associates, Inc., kylstron tubes and transmitters; Westinghouse Electric Co., homing radar and control equipment; Westvaco Chlor-Alkali Division, UDMH fuel; Whittake Gyro., rate gyros; and Yardney Electric Corp., batteries.

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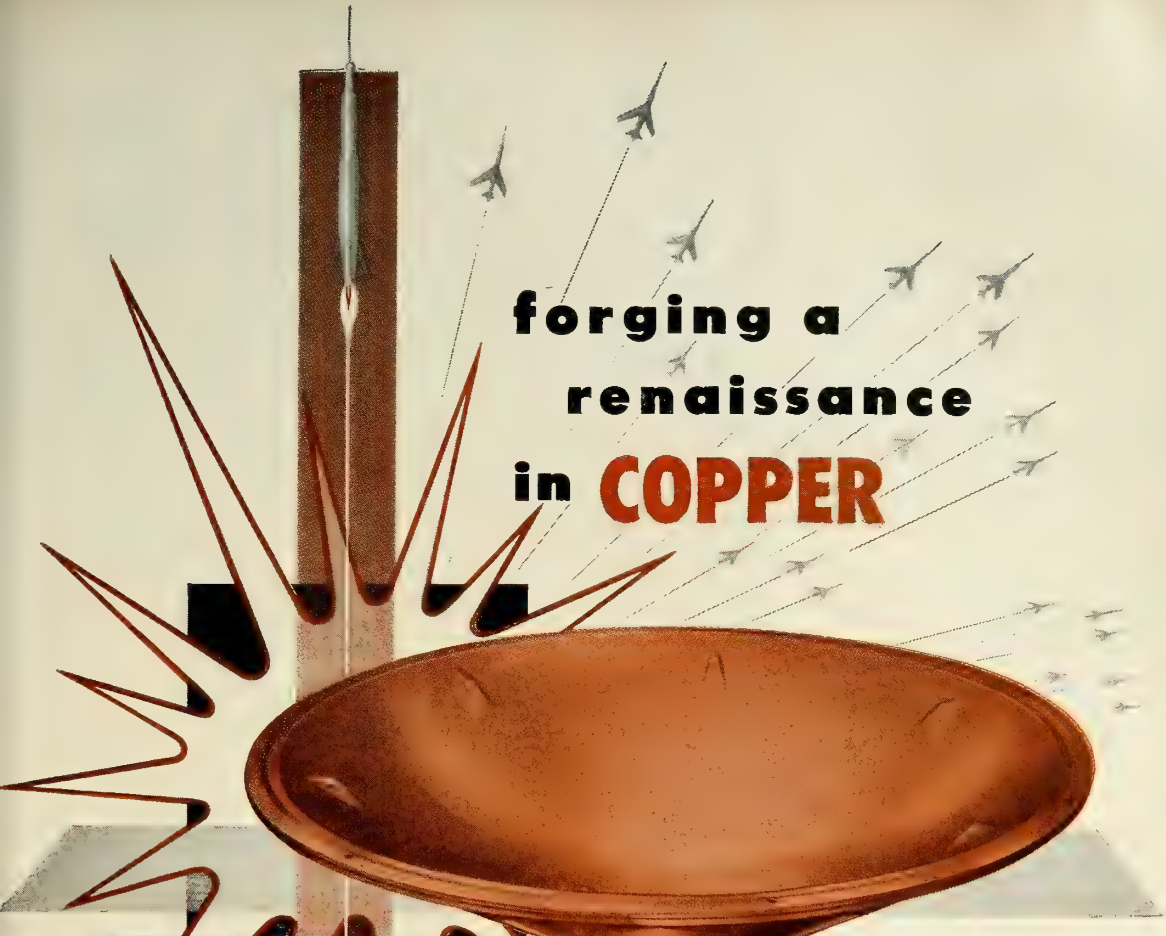

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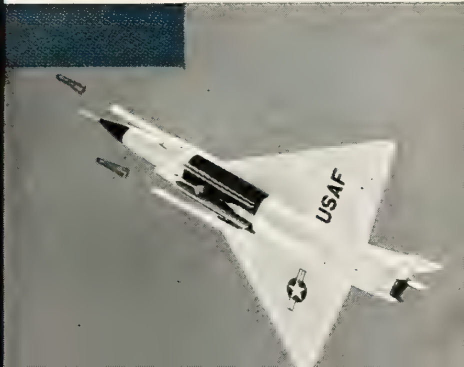

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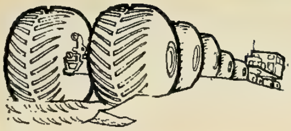

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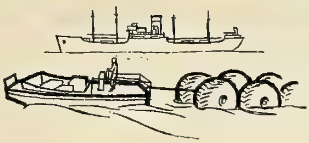

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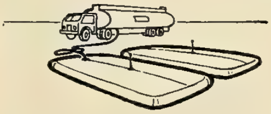

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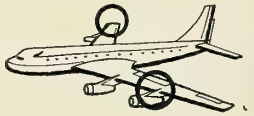

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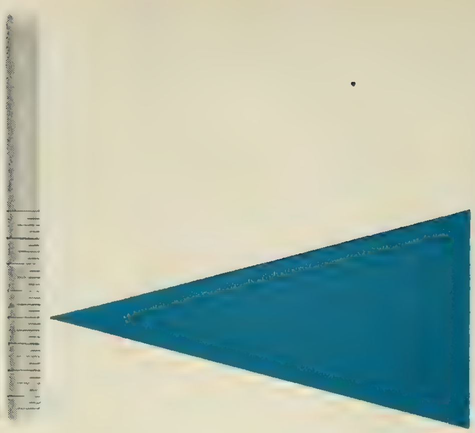

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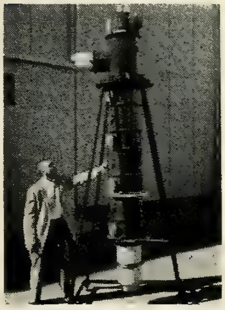
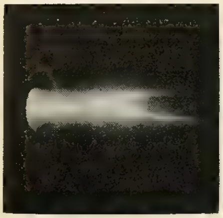
COVER: The power behind Rocketdyne's phenomenal growth is Sam Hoffman (p. 26).

NEW fabrication techniques for tungsten use in missiles have been developed (p. 22).



VARIAN Associates has developed this 12-foot, 900-pound klystron tube for missile tracking.

FIRST *Talos* to be fired at sea leaves the deck of the guided missile cruiser USS Galveston.



PLASMA jet test facility is in prototype operation at ARGMA, giving new capabilities for AOMC (p. 39).

DOW | **MAGNESIUM**

a comparison:

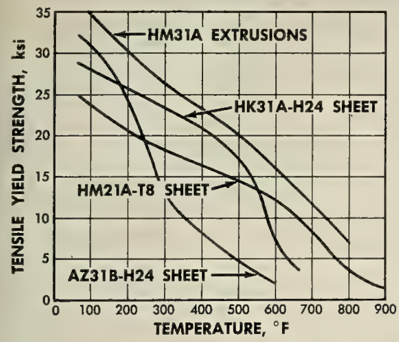
4 MAGNESIUM ALLOYS for elevated temperature service

A wide variety of elevated temperature alloys extends the use of lightweight magnesium into the critical 300°-800°F. temperature range.

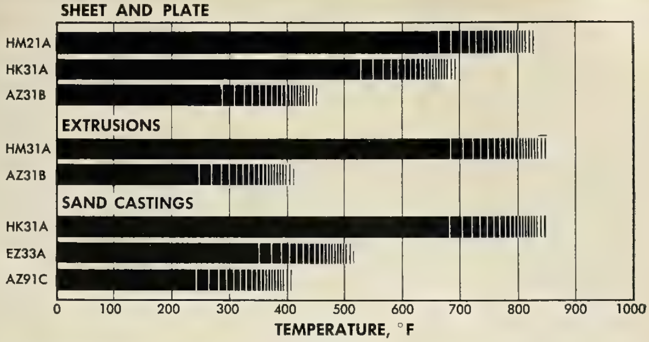
Name your weapon—Jupiter C, Polaris, Talos, Discoverer, Falcon or Bomarc. All make extensive use of elevated temperature magnesium alloys. Improved resistance to creep, increased stiffness and strength and exceptional shop characteristics are the long suit of these materials. At elevated temperatures they maintain a high ratio of fatigue strength to static strength. (About the same ratio as standard magnesium alloys at room temperature.)

SHEET AND PLATE

Alloys HK31A and HM21A have been widely used for many different parts in missiles, rockets and aircraft. Some of the most common applications include body skins, engine air inlets and ducts, nose cowlings and cones, external and internal skins on control surfaces. HK31A extends the usefulness of light-



New alloys have extended magnesium's useful service temperature range.



A comparison of short-time tensile yield strength exhibited by a standard magnesium alloy and the commonly used elevated temperature alloys.

weight magnesium to a temperature of 500°F. and above. HM21A withstands temperatures up to 700°F. and higher for short time periods. And it exhibits better creep resistance above 350°F. and better static properties above 550°F., than does HK31A.

FORGINGS

At operating temperatures up to 800°F., HM21A offers excellent mechanical properties, optimum creep resistance. HK31A has better room and elevated temperature properties up to 400°F. Both have good forgeability.

CASTINGS

Engine air inlets and ducts and housings for electronic guidance systems are examples of the many applications of cast magnesium alloys HK31A and EZ33A. EZ33A has good general properties in the 350°-500°F. range. HK31A is recommended up to 700°F. and above. Components of military systems weighing as much as 105 lbs. have been cast in one piece with HK31A. A new elevated temperature alloy for die casting is now in development and will soon be available.

EXTRUSIONS

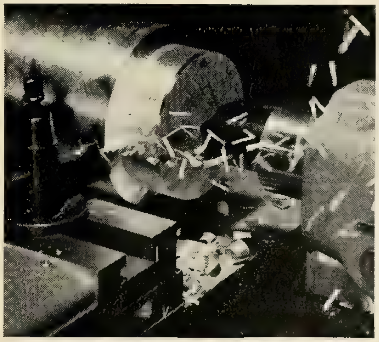
Alloy HM31A has put the many benefits of elevated temperature magnesium into extrusion form. This alloy is used as ribs and horizontals in missile bodies, instrumentation booms and external tunnel fairings for wiring and plumbing, etc. HM31A maintains high elastic modulus, excellent creep resistance and strength at elevated temperatures. Elevated temperature exposure at 600°F. for 1,000 hours causes no change in room temperature properties and only a slight drop in creep strength.

ELEVATED TEMPERATURE MAGNESIUM EXCELS IN PRODUCTION

The elevated temperature alloys possess the best welding characteristics of all magnesium alloys. Arc welded joints can be easily made and welding compatibility of magnesium alloys is excellent. For example, HK31A sheet can be welded to HM31A extrusions.

Weld efficiencies at room temperature range from 70% to 80%. At temperatures above 400°F., HK31A has a weld efficiency of 100%. The same goes for HM21A above 500°F. In general, preheating and stress relieving are unnecessary with these alloys. They can be readily spot welded and are not subject to cracking.

Machining operations can be carried out at extremely high speeds, with heavier depths of cut and higher rates of feed than are possible with other metals. All chemical treatments used to finish standard magnesium alloys are applicable to the elevated temperature alloys, with the exception of Dow 7, which does not coat satisfactorily on magnesium-thorium alloys. For extended service above 400°F., the anodic treatments are preferred.



Elevated temperature alloys possess the same excellent shop characteristics—such as machining, forming and welding—as the standard magnesium alloys.

MAGNESIUM ALLOYS FOR ELEVATED TEMPERATURE APPLICATIONS

SHEET	**HK31A** **HM21A**
PLATE	**HK31A** **HM21A**
FORGINGS	**HK31A** **HM21A**
CASTINGS	**HK31A** **EZ33A**
EXTRUSIONS	**HM31A**

WRITE TODAY for this new 27-page illustrated brochure on magnesium alloys in aircraft and missiles.
THE DOW CHEMICAL COMPANY,
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Magnesium Sales Dept.,
1301CL3-23.

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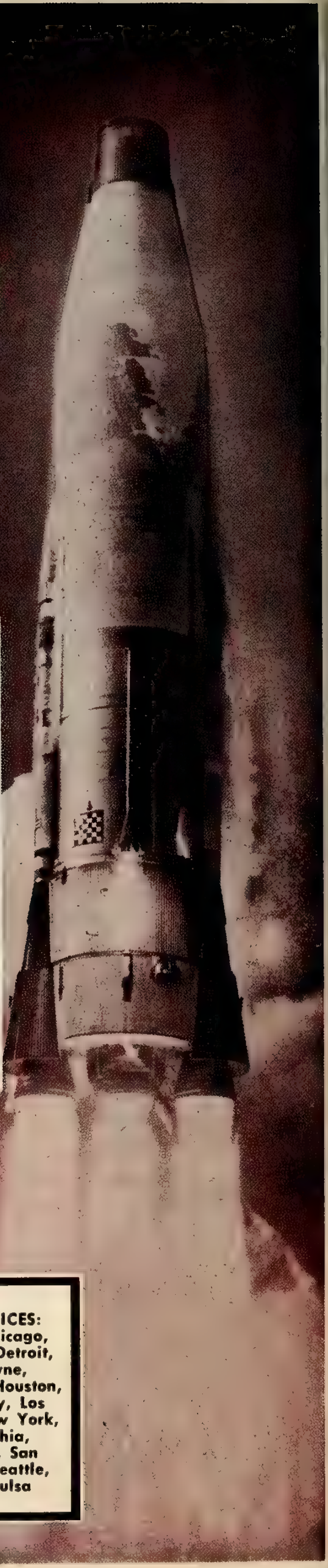
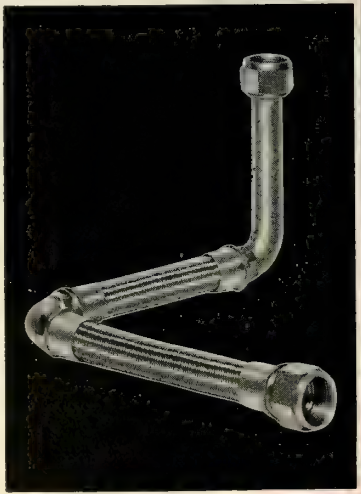
Stratoflex assemblies help fuel
THE MIGHTY ATLAS



Every time a Convair Atlas intercontinental ballistic missile lifts from its Cape Canaveral launching pad, fantastic demands are made of the fueling system and powerplant.

A touch of the blast-off button triggers hundreds of simultaneous chain reactions in the giant ICBM's fuel system. Under tremendous pressure, liquid oxygen is delicately and precisely force-mixed with a kerosene-like fuel and flashes through the lines as vapor to feed the fires burning in the combustion chamber. This blend, mix, fire sequence must commence in a split second and continue at tremendous speed if the launch is to be successful. Fuel line plumbing on the Atlas must be absolutely leakproof, immune to strong vibrations, and able to withstand continuous temperature variations.



Despite the infinite possibilities for human mistake and material malfunction, the Air Force, aided by Convair technicians, has successfully launched the Atlas ICBM time after time at Cape Canaveral. (In the spectacular December 18, 1958 firing, the 85-foot Atlas was placed in orbit around the earth.) Stratoflex is proud that its specially-designed Teflon* hose and metal tubing assemblies are vital parts of the Atlas fuel line system.

* A DuPont trademark

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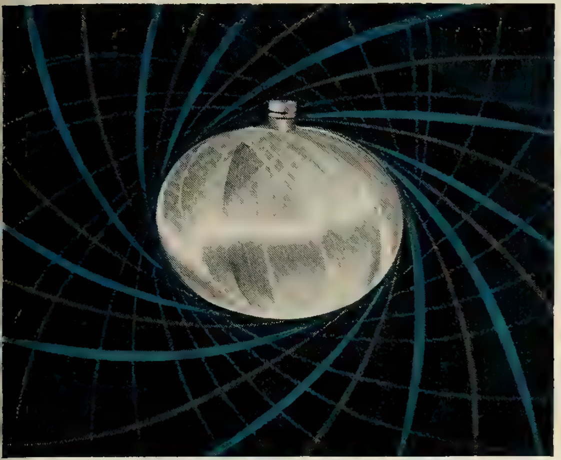
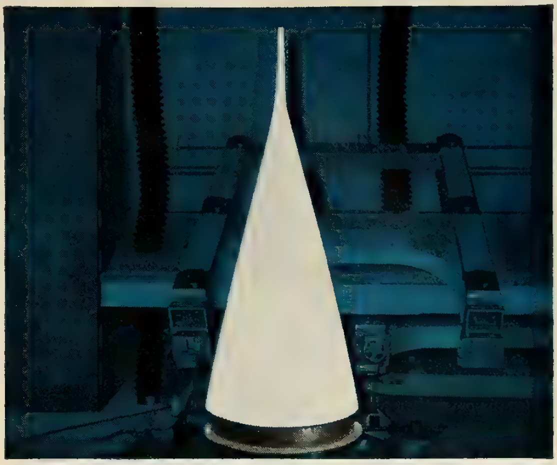
SF1-9

Circle No. 3 on Subscriber Service Card.

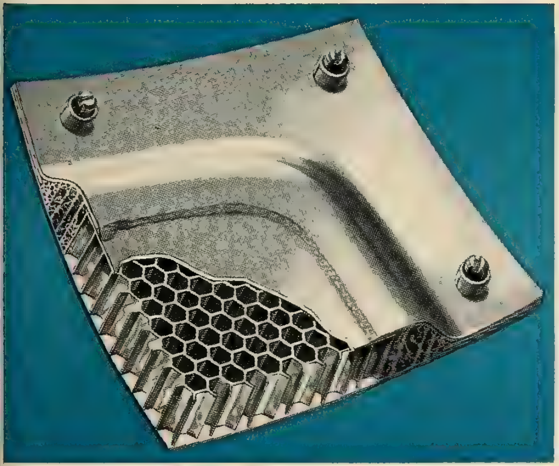
Brunswick technology leads the way in three critical space-age components



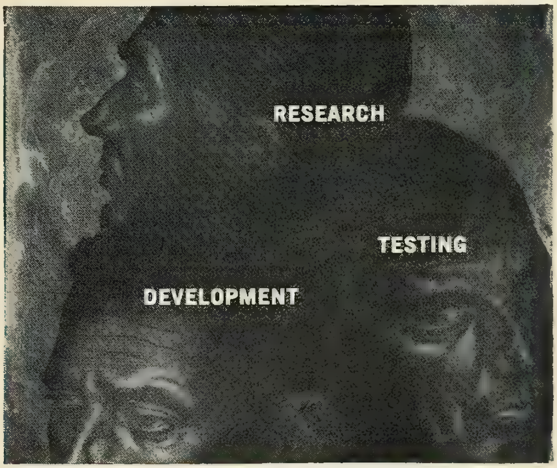
PRESSURE VESSELS AND MOTOR CASES, fabricated by Brunswick's exclusive Strickland "B" Process, now have the highest strength-to-weight ratio ever obtained in filament-wound components. Brunswick is *now* producing these virtually leak-proof pressure vessels. Brunswick also fabricates motor cases capable of withstanding extremely high pressures and temperatures.



RADOMES AND NOSE CONES, created by Brunswick's outstanding research and development efforts and filament winding process, are being used on supersonic aircraft such as the advanced Convair F-106 and McDonnell F4H, as well as on missiles such as the Boeing Bomarc, Lockheed Q5 and similar missiles. And, of course, Brunswick capabilities include complete electronic design and test facilities.



HONEYCOMB ASSEMBLIES, now developed by Brunswick can support two million times their own weight. Brunswick research has created honeycomb assemblies of paper, fiber glass, aluminum and stainless steel as well as conventional forms. Using the most advanced adhesive systems, these assemblies can be formed in compound curvatures with extremely close tolerances.



RESEARCH, DEVELOPMENT AND TESTING—carried on by Brunswick teams have contributed heavily to space-age technology . . . most notably in solving problems of increasingly high operating temperatures (600°–4,000°F.) for critical components and new heights in strength-to-weight ratios. For full information on how this leadership can help you, write or call Brunswick today!

BRUNSWICK

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SYSTEMS MANAGEMENT
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TEMCO®
ELECTRONICS • AIRCRAFT • MISSILES

STRAIGHT TALK FROM
TEMCO | AIRCRAFT DALLAS

QUESTION: What is Temco's experience in the fields of electronics, aircraft and missiles contracts?

ANSWER: During the past 14 years, Temco has successfully completed 35 major programs requiring solutions to engineering design problems in all technical fields involved in the aeronautical sciences. It has produced more than 5,000 components of high performance military weapons systems.

QUESTION: What is the scope of management's knowledge and participation?

ANSWER: Programming under top management is initiated at the earliest project stage and maintained throughout the existence of the job. Overall progress is reviewed at periodic check points, to permit timely corrective action if necessary, and to keep management and the customer informed on the program status.

QUESTION: What are Temco's plant facilities?

ANSWER: Temco has three major plants, comprising over 2,000,000 square feet, fully equipped for the development and manufacture of complete aircraft, missiles and major components. Included is a new Engineering Center with ultra-modern laboratories and experimental design area. Construction is scheduled early this year on vastly increased production facilities.

QUESTION: What are Temco's engineering capabilities?

ANSWER: Temco has over 1,200 engineers whose combination of skills and unique capabilities has established Temco as a leader in advanced technology.

QUESTION: What is the range of Temco's product familiarity and production know-how?

ANSWER: Temco is prime contractor and weapons system manager for the Navy's Corvus air-to-surface "stand-off" missile; it has designed, developed and produced the TT-1 "Pinto" jet trainer and the XKDT-1 "Teal" rocket powered target drone. In the component field Temco products range from integrated antenna systems to high production major assemblies for such advanced aircraft and missiles as the F3H, F-101, F-104, B-52G, Hawk, jet engines and work on classified ballistic missiles. In the modification and overhaul field, activities have spread all the way from "PARC" overhaul of C-97s to development and installation of advanced electronics systems.

QUESTION: What *plus* does Temco offer?

ANSWER: Temco is known by its customers as a "follow-through" company, from design to production . . a partner on the job . . a company that delivers quality products on schedule at the lowest possible cost.

Circle No. 5 on Subscriber Service Card.

Six Lines for the *V-2*

Dr. Walter Dornberger, dean of the famous German "paperclip" scientists who have contributed so much to this country's missile and satellite programs, tells this story (paraphrased) of building the *V-2*, the world's first operational ballistic missile:

"The specifications consisted of six lines. Those lines directed me to build a missile which would do so-and-so. They didn't tell me how to build—just what to build."

In last week's issue of M/R, Managing Editor Don Perry reported that there is grave danger that our military "spec" writers may be endangering the nation's defense system by over-particularizing their orders to industry, particularly in the field of transistors. The report Perry wrote was discussed with M/R's electronics staff and checked in detail with the magazine's editorial board.

It said that in some cases the military contract writers were pushing the state of the art too far by demanding—in weapon systems—complete transistorization of electronic equipment before these relatively new items of electronic hardware have been proven; that the non-solid state devices—transducers and diodes—still require more research in one most important field before they can be cleared for complete operational work. That field is the determination of nuclear radiation effects upon them.

In other words, can our missiles and satellites as they are presently equipped pass through primary and secondary radiation and perform effectively?

The truth is that we do not know. We are not completely sure of it whether they are equipped with transistors or with vacuum tubes, which have been around a great deal longer. In some areas the transistor has been pretty thoroughly tested; in other fields the vacuum tube has been. But there are other fields in which neither is certain.

We have no quarrel with either transistors or tubes. Both are products of the large missile electronics fields which this magazine serves. But we do feel we are doing the nation a service by pointing out industry's viewpoint that neither the transistor nor the vacuum tube is the answer to all evils nor the perfect tool for every job.

Nor do we feel that it is the job, normally, for the gentlemen sitting in the Pentagon, who frequently are a little further away from realism than industry's workmen, to specify in arbitrary detail the minute hardware components comprising space systems. We feel sure there are times when a combination of transistors and tubes, say, might produce a better instrument and that no one is better qualified to say this than the man responsible for building that instrument.

There are evidences that the military's insistence on use of the newer and perhaps more glamorous transistor, with its undeniable advantages of smaller size and less weight, has delayed certain of our military programs. There is evidence in others that revised specifications now call for using whichever device can do the job better, the transistor or the tube.

Again, it is not our purpose to decry either of the two systems, to say that either is better. But we do think it is our job to point out the situation and to point out further that in these days of racing against time for both space supremacy and defense capability, this is no time to be playing tic-tac-toe with destiny.

Every missile and space project this country has achieved has been the product of U.S. industry. No military service really builds an engine or a nose cone or a guidance system. The service job is to foresee the need, come up with the requirement, levy on industry and supervise. In some cases the Army has assembled. But largely it has and always will be industry which produces the detailed hardware.

In doing this industry must have latitude to use the device which will best perform the mission, not suffer under specifications which are both arbitrary and so finely detailed that they can and probably do affect the final performance of the product. The specifications given Dr. Dornberger may have been a little too general. (In those days there wasn't any state of the art; there wasn't any art.) But somewhere between his six lines and the detail of today must lie a reasonable and happy medium.

Clarke Newlon

CEC's 5-119 Recording Oscillograph . . .
First Practical Approach to a UNIVERSAL
Oscillograph . . . Now Available for
Use With DIRECT-PRINT Materials.

New recording versatility with 3 interchangeable magazines

With a new high-actinic light source and Slot-Exit Magazine, the 5-119 now becomes one of the most truly universal tools of data processing available. Addition of the direct-print process and new magazine to the 5-119 now brings you three uniquely different recording processes, enabling engineers to select the process best suited to specific test requirements.

PROCESS 1 DIRECT-PRINT...Clearly resolves writing speeds to 100,000 ips. High-actinic light source 5-119 P4-36V (or -50V) and new 5-051 Slot-Exit Magazine produce records on standard direct-print papers without chemical processing of any kind. Records emerge from the magazine slot continuously, and latensification takes place in ordinary room fluorescent light.

PROCESS 2 RAPID-ACCESS...Provides the shortest access time of any known process, and yields records of higher trace contrast and greater permanency than afforded by direct-print materials. Process employs the 5-036B DATARITE Magazine which automatically develops and dries oscillogram as quickly as data are recorded. Provides ready-to-read test results almost simultaneously with the occurrence of events under study.

PROCESS 3 CONVENTIONAL...Used where the finest available recording trace and contrast with highest writing speed are paramount requirements. Records are contained by the 5-006A Standard Magazine which uses conventional 12-inch films or papers. Records are processed following the record run.

The 5-119 provides 36 or 50 independent data input channels . . . Wide record-speed and frequency-ranges . . . Flash-Timing System to synchronize timing lines of 2 to 100 remote oscillographs. For complete details call your nearest CEC sales and service office, or write for Bulletin CEC 1536-X5.

Electro Mechanical Instrument Division CEC

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- *missile-quality*
- *high reliability*

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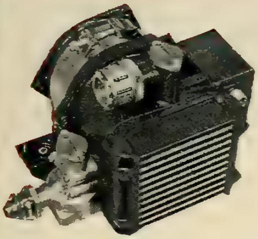
New Pesco fan designs are constantly being developed for new applications, environments, requirements. Built-in Pesco electric motor, custom-designed for each application, assures maximum efficiency and reliability. Capacities from 5 to 5000 cfm. in 27 volt d-c, 400 cycle a-c and special designs for cooling airborne and ground electronic equipment, helicopter engine oil, missile support systems.

new ELECTRONIC COOLING PACKAGES



Pesco electronic cooling packages are remarkably smaller, lighter, quieter, simpler. Integral, miniaturized design eliminates external tubing and fittings, avoids leakage problems. All components are Pesco—**assuring single source responsibility,** matched performance, less maintenance, faster delivery. Specially designed for ground and airborne applications.

These new accessories exemplify the advanced production models available to meet today's aircraft/missile performance demands. Undivided responsibility for component design and production enables coordination in the development of each new system or accessory. True systems engineering assures matched component performance and maximum reliability.

When you need a fresh approach to accessory system problems, take advantage of Pesco's facilities and advanced designs.

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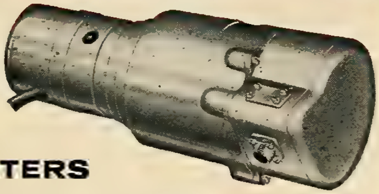
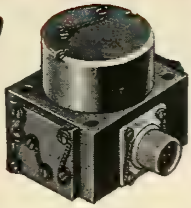
new INVERTERS



For d-c to a-c inversion in missile secondary power systems, Pesco Inverters provide maximum reliability, miniaturized package design and simplified, rugged construction. The Pesco electric motor, speed control and alternator are built integrally on the same shaft. Models are adaptable to applications within the 26 to 56 volt d-c input range. Output may be either single or three-phase, 400-cycle a-c up to 12 kva. Inverter maintains output voltage to ± 1.0% with ± 2.5% output frequency variation.

new SERVO VALVES



High-fidelity Pesco Servo Valves are electro-hydraulic transducer type, feature unique flow-sensing principle. Meet toughest missile requirements with excellent system stability, insensitivity to operating variables and dirt, minimum null shift, fast response, faithful reproduction of smaller input signals, minimum threshold and dead zone. Miniaturized and designed for consistent, high-quality mass production.

watch Pesco for continual new developments in:

- **high-speed, high-temperature hydraulic pumps and motors**
- **fuel, fuel booster, cryogenic and propellant pumps**
- **power packages**
- **secondary power systems**
- **air pumps and motors**

PESCO... *means progress in aircraft/missile systems and accessories*

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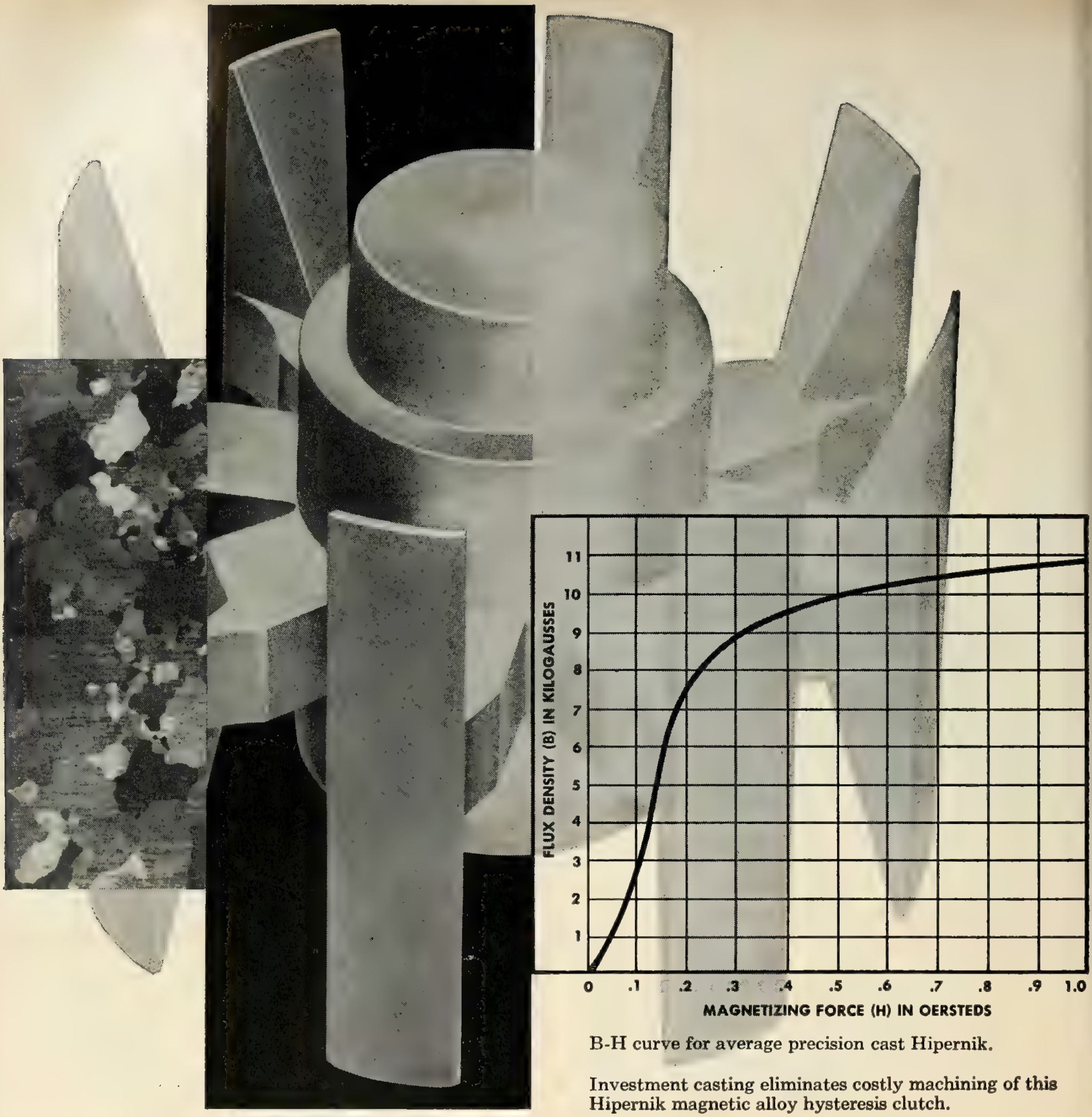

B-H curve for average precision cast Hipernik.

Investment casting eliminates costly machining of this Hipernik magnetic alloy hysteresis clutch.

Westinghouse Hipernik Casting

...cuts costs, retains magnetic properties

The field of electronics has created special metal problems. The Westinghouse Metals Plant has accepted and solved some of these problems.

Cast Hipernik® is particularly adaptable to the requirements of missile control systems. Other applications in the electronic control and instrumentation fields are transformer cores, pole pieces, solenoids, torque motors, magnetic clutches and many special magnetic applications.

The Westinghouse Metals Plant may be able to cut your costs by eliminating unnecessary machining, yet delivering to you a completely finished component ready for assembly. This modern metals plant can furnish strip, sheet and bar stock in other magnetic and high temperature alloys. Write to: Westinghouse Metals Plant, Blairsville, Pennsylvania. Our latest bulletin on Hipernik will be sent to you by return mail. J-05005

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washington countdown

Three more ICBM bases . . . have been announced by the Air Force. They are near Ellsworth AFB, S.D. and Mountain Home AFB, Idaho, for *Titan* and Schilling AFB near Salina, Kan. for *Atlas*. This brings to 10 the number of ICBM launch sites announced thus far.

Some 60 possible promotions . . . retirements and reassignments of Air Force general officers are being considered by Defense Secretary McElroy, many of which must go to Congress and the White House for final approval. It may be some time before the list is finally decided upon but one promotion and reassignment may be pulled out and ahead of the rest. That would be the third star for present Maj. Gen. Bernard Schriever and his assignment to be commander of Air Research and Development. His present job is CG of the AF Ballistic Missile Division.

The mystery firing . . . at Cape Canaveral a few days ago was another tryout of McDonald's two-stage, solid fuel air-launched ballistic missile, code named the *Draca*. McDonald is one of several companies in the ALBM competition.

Mail by missile . . . is under consideration by the Post Office Department as an experiment sometime this year. A PO spokesman said in answer to questions that the project still is in the "think stage" but that the department is "most anxious to keep abreast of the times" in mail delivery. He said the test vehicles probably would be obsolete *Snark* or *Regulus* missiles.

Reconnaissance satellite program . . . expected to change hands. Chances are good that NASA will take control of *Discover* and the follow-on but probably not WS-117L, *Sentry*. Transfer won't be made by ARPA until next fall. Idea is that State Department would like to convince Russia that satellite is for peaceful purposes only. Meteorological satellite will be transferred by ARPA July 1. It is a 250-pound vehicle carrying an RCA television said to be so sensitive that it shows 500 lines to a millimeter.

Man of the hour . . . In Washington last week was Dr. John P. Hagen, director of the Vanguard project. He received the Navy's Distinguished Civilian Service Award, and was guest of honor at a reception and dinner marking the first anniversary of the launching of the *Vanguard I* satellite.

Carrying a source of energy . . . space . . . into space is a major problem, Hagen said. One solution is seen in the solar cell still supplying power for transmissions from *Vanguard I*. H. Leslie Hoffman, president of Hoffman Electronics Corp., said the cells, originally conceived by Bell Telephone Laboratories, and developed by Hoffman, had been increased in efficiency by about 400%. He predicted a broad use of the cells as a power source in space vehicles.

Compulsory competitive bidding . . . for defense contractors got further support with the introduction of a bill by Sen. John J. Williams (R-Del.). Williams said the bill was prompted by reports from the General Accounting Office. It provides contracts must be awarded to lowest bidder except when unfeasible from a national security standpoint.

Major weapons system managers . . . can expect summons from House Armed Services subcommittee. Chairman F. Edward Hebert (D-La.) said last week a comprehensive procurement investigation "is long overdue." He said some critics of weapons system procedure call it a "blank check." The "administered price" will come in for a lot of attention in the new investigation, he said. At least four manufacturers have been advised by the committee exactly what kind of information the subcommittee wants regarding financial arrangements, performance rates, facilities, termination costs and cost allowance. Hearings are scheduled to begin after the Easter recess ends April 6.

solving today's problems today: Burroughs 220 Computer

In scientific computation and business data processing, the new Burroughs 220 is delivering tangible results today. Linking a powerful digital computer to equally powerful input-output subsystems, the 220 offers balanced performance at the lowest application cost. Its expandable core memory, built-in floating decimal arithmetic, vast Datafile magnetic tape capacity and the multiple-card processing ability of Cardatron make this the most powerful system available in the medium price field. The 220 is just one part of a complete line of advanced Burroughs electronic data processing equipment...now in production...now at work in hundreds of installations...supported by an outstanding team of computer specialists. Write today for 220 brochure, ElectroData Division, Pasadena, California.

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Research: opens the door to space

Space Technology Laboratories is responsible for the over-all systems engineering, technical direction, and related research for the U.S. Air Force Ballistic Missile Programs. To carry out the fundamental investigations of those physical phenomena related to very advanced and long-range problems of space technology, STL established the Physical Research Laboratory.

This laboratory is making significant contributions in experimental and theoretical research in the fields of controlled fusion and associated plasma physics, magnetoaerodynamics and low temperature solid state physics.

Dr. Milton U. Clauser, Vice President of the Company and Director of STL's Physical Research Laboratory, draws upon a rich background of industrial, as well as academic, experience and achievement in charting the areas of research that will be important to the space technology of the future.

The professional staff of the Physical Research Laboratory, the majority of whom hold the Doctorate, are supported by unusual shop facilities and a complete staff of technicians. Also available is an outstanding digital computing center within the STL complex. Scientists and engineers with competence and imagination in fields related to advanced cryogenics, fusion physics and magnetohydrodynamic investigation, are invited to inquire about Staff positions.

Space
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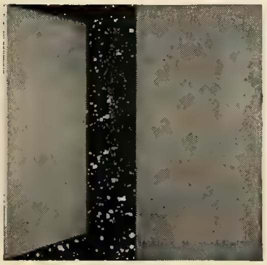

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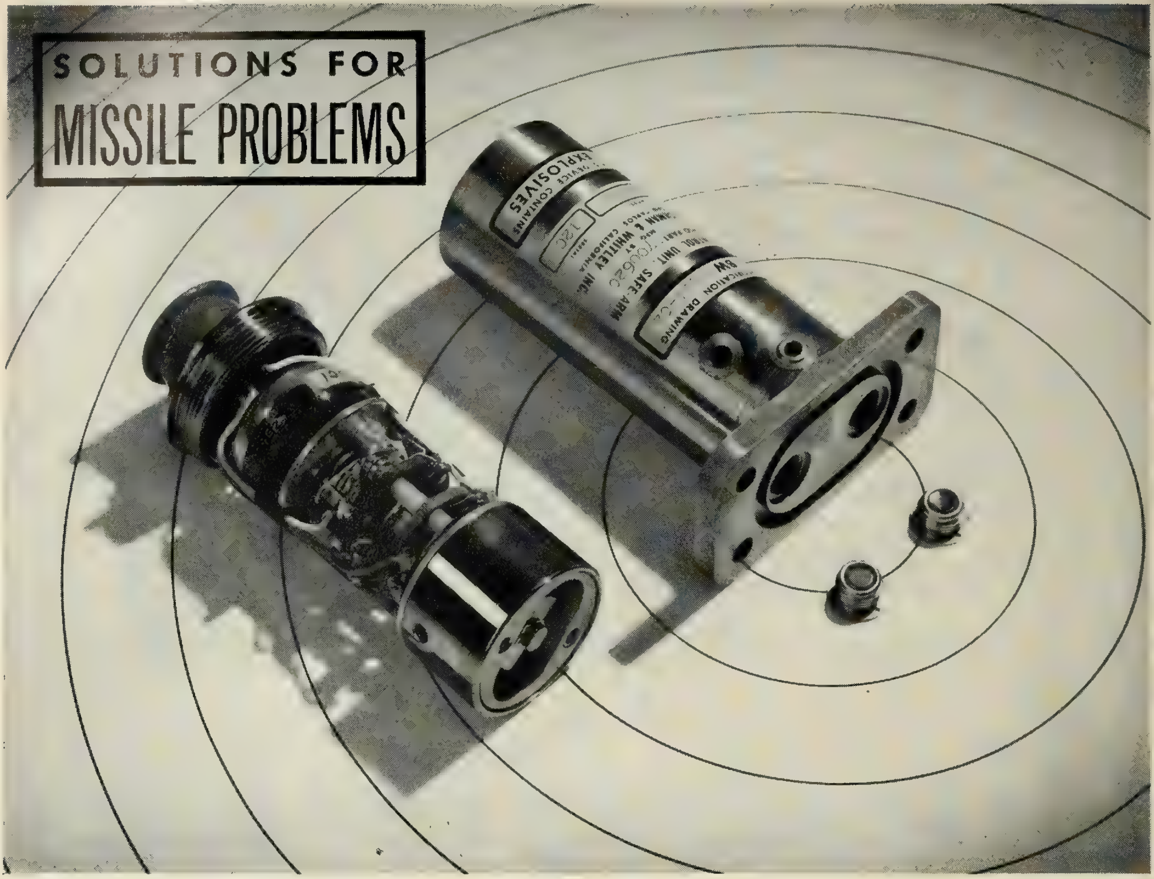

safe/arm initiators

Ten years of pioneering in the missile component field has made possible this new line of Beckman & Whitley solenoid-operated safe/arm explosive initiators. Unit on the left has cover removed to show internal arrangement.

Weighing only 1.85 lb loaded, this model is 5 in. by 3 in. by 1¾ in. It was designed to military requirements. It can be armed or disarmed by remote electrical signal and includes both visual and electrical telemetering facilities for indication of armed or disarmed condition. On reception of a command firing signal, the unit will initiate associated primacord, low-energy detonating cord, (LEDC) or bulk charges.

This may be just what you need. On the other hand, Beckman & Whitley can provide the engineering capability, the production facilities, and perhaps most important, the speed necessary to give you anything you *do* need in the line of propellant-actuated devices.

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industry countdown

NASA will control . . . design and development of all space-missile propulsion projects after June 30. On that date, the space agency will take over control of *Centaur*, second-stage liquid nitrogen-propelled rocket being worked on by Convair and Pratt & Whitney.

***Centaur's* second-stage . . .** incidentally, consists of two 15,000-pound-thrust rocket engines using liquid hydrogen. It may also have a third stage same as *Vega* with 600-pound thrust under development at JPL. The combination reportedly is 50% more powerful than *Vega*.

Work with new HILAC . . . atom-smasher at University of California's Lawrence Radiation Laboratory points toward revising the belief that cosmic radiation will damage humans in proportion to the weight of each type of atomic nuclei. An AEC-sponsored program indicates that damage increases with nucleus weight only up to a certain point, then levels off.

Fluorine-based liquid fuels . . . will out-perform proposed boron-based solids in payload-orbiting ability even if the latter come into being soon, according to a Rand Corp. research engineer. The expert, Martin Goldsmith, says in a report that this is true even though the boron-based fuels may give higher specific impulse than present LOX hydrocarbon combinations. He added that solids will always require heavier vehicles than liquids for a given job of orbiting.

Frame contract bids . . . for Project *Scout* should be opened on Monday, March 23. Between 20 and 25 bids are expected.

Titanium prices will drop . . . to about $1.50 per pound ultimately, in the opinion of metals experts. The say a large commercial market for the metal has yet to be tapped.

Tensile strength of 750,000 psi . . . in some steel alloys is "within reach," according to metals people. The ultra-high-strength steels have far surpassed their former characteristics and are now considered "new" metals.

***Snark* production is programmed . . .** through calendar 1960, despite misleading statements to the contrary, Production models, painted grey, continue to roll out of Northrop's facility at Hawthorne, Calif. Checkout before delivery to SAC is being done at the Norair Division.

About $1,770,000 will be spent . . . on initial construction of limited *Minuteman* test facilities at Edwards AFB, Calif., the Air Force says. The construction, now underway, will include buildings for instrumentation and control, assembly and shopwork. Additional component testing will be done at Holloman AFB and the complete system eventually will be flight tested at Patrick AFB.

Secode Corp. of San Francisco . . . a developer of electronic communications equipment, has acquired a "substantial" interest in C. A. Rypinski Co., Southern California producer of regulated power supplies for missiles.

***Polaris* exhaust nozzle liners . . .** have been contoured by forming molybdenum forgings into the desired shape by hydrospinning at 1000° F. The advanced process was carried out at the Wright Aeronautical Div. of Curtiss-Wright and described recently in C-W's annual report. The report also noted that the division was involved with development of inert components of propulsion for *Minuteman* and *Pershing* as well as *Polaris*.

A weapons system management . . . proposal for an Air Force ASM is being prepared by Northrop-Norair. Team members include Nortronics, ITT, AVCO and Aerojet-General.

One of the most modern . . . printed circuit manufacturing facilities opens on April 15 when the U.S. Engineering Co., a division of Litton Industries, moves into a new plant at Van Nuys, Calif. It will be the "only fully integrated printed circuit operation in the country," according to Jack Gentry, USECO's general manager. The plant should be in full production by the end of April.

T/I combat surveillance

Stay 'home' and see more

Aggressor terrain and positions are open secrets to TI-equipped recon drones and snooper aircraft. Field commanders can now reconnoiter "in person" far behind aggressor lines *without leaving field HQ.* Instant, accurate, continuous data on thousands of sq mi of hidden territory can flow into headquarters *in the time one foot patrol could complete its mission.* Hundreds of targets can be spotted, evaluated and brought under fire in the same time interval . . . most of them within seconds after detection. *This capability exists now at Texas Instruments.* For detailed discussion, military and industrial personnel with need to know please write or call: SERVICE ENGINEERING DEPARTMENT.

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MARCH 23, 1959—VOL. 5, NO. 12

missiles and rockets

MAGAZINE OF WORLD ASTRONAUTICS

Some Views of DOD Research Chief York

Pentagon's first R&E director gives priority to weapons system on basis of importance of its mission and encourages industry to do more research on its own. He will add new offices to bolster the development present set-up.

by Paul Means

WASHINGTON—Dr. Herbert F. York, first man ever given the power to direct the Department of Defense's entire research and engineering program, has told M/R he intends to:

- Assess the importance of a new weapon in relation to its' mission and not its components and environment.

- Engage industry to do more research . . . with less of it becoming systems work.

What goes on behind door 3E-1006, Pentagon has been a question of great curiosity and concern to Congress, the military, industry, the press and the entire nation ever since Dr. York was assigned this room in December as the first Director of Research and Engineering.

Recruiting with a big R is one of the major activities conducted behind the door. An interview which took months to schedule will be interrupted constantly while the new Director talks long-distance to a scientist or engineer he feels is needed to carry out the task of the new office.

The recruiting will continue until Dr. York's team has a few more than 100 members whose duty it will be to direct the expenditure of $5 billion that will be spent on the thousands of DOD R&E projects in fiscal '60.

• **Problem of priorities**—One of the big problems that has plagued centralized Defense planning is: Where should the money go? Which new service project or weapons system is the most important?

Dr. York hopes to resolve this problem by evaluating the new weapon in relation to its mission instead of its environment or components.

He uses the early warning, navigational, and communications satellite projects as examples of what he means. The importance of these projects should be evaluated primarily in relation to the entire air defense, navigation and communication systems, and not solely in relation to the space program or in relation to their boosters.

"How does the communications satellite fit into the entire communications Program?" This is the question Dr. York's office will ask in evaluating the need for such a satellite, and in deciding how fast its R&E should progress. The questions of where it fits in the space program and where it fits in the booster development program are secondary to the importance of its mission.

Dr. York intends to apply the same analysis to missiles, aircraft, ship propulsion, nuclear and conventional weaponry, propulsion, ground support, ground transportation, better bullets, materiel, food, blood preservation, and all of the major Defense R&E projects.

• **New offices**—To implement the evaluation of R&E projects in relation to their mission, Dr. York intends to augment the present offices dealing with the specific technical fields of aeronautics, electronics, atomic weapons, fuels, and guided missiles, with offices which will deal with overall military missions, such as air defense, tactical weapons, strategic weapons, communications, etc.

Dr. York considers these new "mission" offices important enough to be headed by Assistant Directors.

Under such a system, Dr. York should be able to assess with greater reliability which new project is most important, needs the most money, and should progress at the faster rate.

• **Industry research**—Another problem which Dr. York hopes to correct is the time and expense wasted on R&E for weapons systems which it is found later do not work or are not needed.

Dr. York said that he was going to see that industry does "more exploratory work, and that less of that kind of work becomes systems work."

He hopes to cut the tremendous cost of industry weapons development by supervising industry R&E, and cancelling projects when it is determined that it will not result in a workable or needed component or weapons.

"We have to explore as many areas as possible, but it is difficult to limit exploratory efforts," Dr. York said. "When a contractor carries on extensive exploratory work on one project, he tends to think that his way is the only way to solve the problem."

Much of this evaluation is already done by the Systems Evaluation Group, whose scope of activities Dr. York intends to expand.

• **Selective approach**—Direct supervision by his office will be limited to the major projects. Dr. York points out that there are thousands of R&E programs and his small office could not hope to direct the spending of $5 billion in detail. He said his office will pick those projects which he feels are important, and will keep track of the others.

Dr. York feels that his relationship to the Advance Research Projects Agency, which has the job of tying the military space program together, is identical with his relationship to the service R&E offices, and that ARPA projects will warrant the same type of direction from his office.

Besides evaluating R&E projects as to their relative importance in relation to the mission they perform, Dr. York feels his department must fight for those programs which are not as glamorous as others.

"Most of what we are doing is not shooting things up into the air. An important part of our job is to see that programs not as glamorous receive sufficient planning. We must make sure that no important projects are left out —or that none are left out because they are only half-important to two services," Dr. York said.

• **No conflicts**—Dr. York sees no conflict in goals, confusion, or duplication in the present science and military space programs. There are different programs he said, because different organizations have different missions in space.

(Continued on page 36)

Fansteel research opens new applications for missile electronics, propulsion and structures

RECTANGULAR PIECES are "boats" for containing small parts in furnaces, and round cups could be gyroscope rotors.

'Breakthrough' in Tungsten Fabrication

by Donald E. Perry

CHICAGO—Tungsten—twice heavier than iron but with the highest melting point of the refractory metals family —should assume important applications in missile and space vehicles if research in pure tungsten fabrication by the Fansteel Metallurgical Corp. is an indication.

Until last summer, tungsten was being fabricated in relatively simple shapes. Today, Fansteel has reversed the fabrication picture. Here's what the company is doing:

- A deep drawing process has been developed. To the company's knowledge it is entirely new within the last six months. It gives about a 20% increase in density over tungsten alloys now being used.
- Parts, while small to be sure, have been fabricated from tungsten sheet by spinning the almost unworkable metal.
- **Self-financed**—Fansteel's research to explore use of tungsten for rocket nozzles, electronic components and re-entry nose cones is self-financed. Most of today's government-sponsored research for rocket applications is going into molybdenum, with half the weight of tungsten and a melting point of 4752°F, compared with tungsten's higher 6152°F.

But Fansteel feels that expanding present limits of tungsten fabrication will make possible an endless stream of component parts for the missile industry.

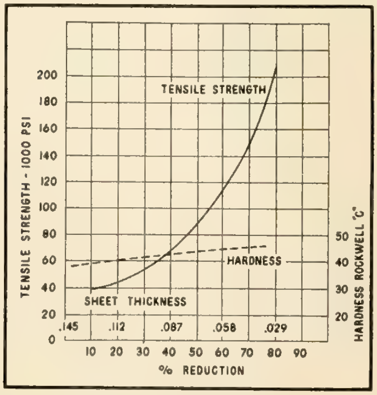
For example, deep-drawn tungsten boats will make it possible to fire electronic tube components to higher temperatures so that better tubes can be mauufactured. And, there is the possibility of designing continuous metal evaporating equipment which in turn would reduce processing costs.

Most important, design engineers can consider deep drawing of tungsten sheet metal parts for vector control of rockets. Since the rocket nozzle is one of the most severely stressed parts, Fansteel believes there are tungsten requirements.

As rocket performance requirements increase, flame temperatures will become higher than molybdenum can withstand. Tantalum is being tried, but Fansteel thinks maximum performance will not be possible until tungsten is used.

While Fansteel is generally regarded as the leader in the tungsten field, it—like many other companies—is in deep with other refractories: tantalum, moly, and columbium.

- **Binding challenge**—One possible use of tungsten in rocket nozzles would be to bind it to stainless steel in the throat section and allow the tungsten to take the punishment. However, this would add weight and pose a tremendous—but not impossible—binding problem. Use of nickel with tungsten probably would be a logical step.



TUNGSTEN STRENGTH increases with work. Curves show effect of roll-reduction.

Fansteel points out that deep drawing and machining can extend the use of pure tungsten for gyroscope motors. With about a 20% increase in density over tungsten alloys now being used, a drawn rotor may make it possible to decrease the size of gyro controls and yet retain their operational integrity. Tungsten has the lowest coefficient of thermal expansion of any of the metals presently used in rotor construction, Fansteel says.

- **Brazing**—Using gold, which has the same density as tungsten—19.3 grams per cubic centimeter (lead is 11.3)—as the brazing agent, Fansteel has come up with a miniature-sized container made from two drawn tungsten cups which can hold radioactive materials.

R. W. Yancey, consulting metallurgist in the metals and fabrication division, cites an interesting possibility for this process. He envisions two drawn tungsten cups brazed together at angles with gold that would be about the size of a potato. By drilling a hole in the bottom of one of the cups prior to assembly, it could be used as a radioisotope container.

In the *SNAP III* (secondary nuclear auxiliary power) project, decay of a Polonium 210 isotope created heat energy which was captured by thermocouples and produced five watts of power. Yancey believes tungsten could well serve as the casing for such power packages.

APPROXIMATE LIMITS of tungsten fabricability as of six months ago. All of this forming, of course, is done hot.

PARTS FABRICATED from tungsten sheet by spinning, an art dating back to Middle Ages but new to refractory metal.

• **Background**—Within recent years there has been a tremendous increase in interest and use of pure tungsten products or alloys containing a high percentage of tungsten.

While powder metallurgy has resulted in many high density products, the mechanical properties of these alloys have depended on the nature of the cementing agent, the weakest link. Melting point, density, high-temperature strength, modulus of elasticity of the alloys and other properties have been inferior to those of pure tungsten. Another drawback has been the difficulty of working the powder metallurgy product except by machining.

Another important reason why pure tungsten has not been used more extensively is the ratio of cost to economical performance. This has left little incentive to develop new manufacturing techniques in wrought tungsten, Fansteel feels.

However, the emphasis has changed rapidly in recent months. Today the military is emphasizing performance rather than cost. Factors influencing this emphasis are greater reliability and longer life in electronic components; processing materials at higher temperatures; and manufacturing of sturdier components and assemblies which can operate at high temperatures.

• **The tungsten problem**—Fabrication is exceptionally hard because it must be heated to temperatures at which stainless steel and some of the super-alloys would melt. Its working has to be done at a high temperature and must be done quickly.

After preliminary working, continued working is less severe. But here another problem enters the picture: As tungsten cools to a temperature approaching 800°F, it rapidly loses much of its ductility and rapidly gains in strength. Working tools have to be fabricated from an alloy that has good high-temperature strength, plus an ability to withstand considerable wear.

Forgings are made in a series of steps, taking advantage of more ductility as the metal is worked further.

Another new Fansteel development is seamless tungsten tubing produced by hot extrusion. A tube was reduced by 70% of its original area, showing the extent that hot tungsten would flow under proper conditions. The extruded tube possibly could be used for drawing thinner-walled tubing, or it could be hot upset to make a special shape.

Materials for space vehicles—not only in power plants but in skin surfaces as well—pose uncertainty and difficulty. The requirements are basic: they must be easily formed into large sheets, welded, cast, or wrought to the desired contour.

Tungsten by its very nature is tryingly difficult, but Fansteel believes its research into new fabrication processes is crossing a metals frontier.

Plenty of Work for Small Firms, MIT Forum Is Told

NEW YORK—Convair's chief engineer predicts that a few companies with "demonstrated capabilities" will be given the responsibility for developing major systems in America's space program.

However, Mortimer Rosenbaum, head of the Convair technical staff that developed the *Atlas,* said here recently that other companies would have plenty of opportunity for subcontract roles.

Rosenbaum was a principal speaker at a forum on "Conquest of Outer Space" held at the annual technical dinner meeting of the MIT Club of New York.

The 300 attending also heard:

1. A top test pilot declare that qualified pilots lack enthusiasm for the Project *Mercury* man-in-space plan because it is so automatic that the pilot has no control over his destiny.

2. An industrialist call for more research in metal strengths.

• **Sharing in** ***Atlas***—Rosenbaum said subcontractors handled 50% of the job General Dynamics' Convair Astronautics Division did on the *Atlas* major system. Of this subcontracting, 36% was done by small businesses.

There is room for small companies to do specialized work, too, Rosenbaum continued. As an example, he cited McDonnell Aircraft's victory on the Project *Mercury* capsule contract, bidding against G-D and other large companies.

• **Pilots balk**—Ralph Cokely, engineering test pilot for Boeing Airplane Co., told the forum he had yet to find a qualified test pilot who wants to test the Project *Mercury* capsule.

"A man should be given alternate means of manned control," Cokely declared.

The test pilot said there had been a trend in recent years toward building of aircraft with red and amber lights rather than gauges to indicate actual conditions.

"It is better to have a temperature gauge that predicts the problem before it arises than a flashing light, that tells you when it's too late," he asserted.

• **Metals work urged**—Everett T. Welmers, assistant to the president of Bell Aircraft Corp., told the audience that space technology requires considerable basic research in the reaction of metals to temperatures measured in the thousands of degrees.

"We have made considerable progress recently in chemistry, particularly in plastics," he remarked, "but we haven't gone so far in the field of metals. With many metals, we still are using techniques thousands of years old."

World Must Solve Brand New Problem of Moon Rights

Authorities seeking answers find few precedents to work with and most consider U.N. control the most feasible.

by Donald Cox*

BALTIMORE—Now that the Soviets have sent their *Mechta*—dream rocket—within 4600 miles of the moon on its way to solar orbit, we are suddenly aware of the problem of the ownership of our lunar orb.

Who owns the moon anyway? God? . . . Gamal Abdel Nasser? . . . The Soviet Union? . . . The United States? . . . All mankind? . . . This question was academic before October 4, 1957, and was semi-dormant before January's *Lunik,* but now it is a pressing matter which in the very near future may be causing our State Department, Department of Defense and United Nations legal representatives loss of sleep.

For at the moment that the U.S. or the U.S.S.R. splashes the instrumented nose cone of a rocket on the dusty surface of our moon, the controversy over ownership will flare up into major proportions. For this reason, it is important that the various alternatives on ownership and control of the moon be examined now, calmly, so that we will be prepared for a better understanding of the problem when it becomes a stark reality . . . which it should someday this year!

• **Staking claim**—This problem will be complicated further in a few years when the first man lands alive on the moon or circumnavigates it in a close-in orbit. Will the nation who sends the first man safely to the vicinity of the moon gain sovereign rights over its territory? Will the old rules of exploration which were applicable in the great days of the discovery of the New World still apply to the moon?

The precedents of international law would tend to lead one to believe that planting an unmanned radar beacon in some lunar crater or mountain top might be a sufficient basis for a national claim to sovereignty by the nation which put it there. Fortunately, however, international law is a living organism and is subject to change, having passed through many stages of growth in the past.

Now, in its greatest moment of ascendancy, international law will probably have to look elsewhere than to the past to learn who should own and control celestial bodies like the moon. Since the moon undoubtedly will be the first focal point of man's space exploration, it will serve as a "live" guinea pig in the struggle for ownership and control of other bodies—the planets and their moons.

• **Four leading theories**—It is fairly obvious that we will not turn our backs on the ticklish subject of lunar ownership or conquest whether it be under a military or scientific banner, or both. If we did put our heads in the sand like the proverbial ostrich we would be burying our chances to participate in the last great adventure of mankind—the exploration of space.

But in facing up to our destiny and continuing our national plans to land on the moon, we will run the risk of meeting some "other national" lunar explorers head-on in some well-known lunagraphic terrain feature. Before that moment arrives, we might well spend some time examining four theories of possible lunar ownership and control and their consequences.

1. **National lunar subdivision concept**—As various nations send their human "space" representatives to the moon, some theorists believe, less friction will evolve up there and back here on earth if the moon is sliced up like a giant pie, subdivided into massive triangular real estate holdings and doled out to the interested nations by some previously-agreed-upon international lunar real estate corporation This "lunar suburb" theory holds that a subordinate body of the United Nations could be set up to divide the moon in advance, with the size of the slices being determined by population and relative power here on earth.

Each earth nation could indicate those areas or pie-slice parcels that it desired to explore and colonize. The large, underdeveloped nations of Africa and Asia—not yet technologically ready to participate in a mass colonization attempt—would have their plots held in escrow by the U.N. body.

This theory has many loopholes, including a considerable doubt that the nations of the earth would agree to such a plan. It is further complicated by the fact that mapmakers here on earth along with lunar real estate salesmen and legal experts might have trouble deciding which wall of which crater belongs to one nation rather than to another.

This concept probably is the least workable of the four.

2. **First come-first served**—Some experts feel that the first nation to reach the moon and establish a claim with an unmanned rocket or a manned lunar base could theoretically claim the whole of the moon as its own "seventh continent" of the earth. Although the Soviets did not say so at the time, the official photos of the *Lunik* sphere showed it liberally adorned with the hammer and sickle and "USSR" painted all over its surface.

This can only be interpreted one way: had *Mechta* impacted on the moon's surface while it was still called *Lunik,* the Soviets might have claimed the entire moon. Only when it was obvious that *Lunik* would miss the moon by several thousand miles did the Soviet propagandists slyly change the name of their instrumented payload to "Dream."

Even though *Mechta* missed its target, it emphasizes the coming problem of recognition or non-recognition for the nation that first "plants its flag" on the moon. Whether recognition is granted by individual nations, like the Soviet satellites, or an international body, like the UN, is a minor point, if such an event occurs in the very near future.

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* *Donald Cox, a frequent contributor to m/r, is the co-author of the book, Spacepower.*

What is more important is the ability of the nation that first lands an object on the moon to deny landing rights to other nations. Unless the first nation establishes many manned lunar military bases, it probably will find that it is almost impossible to prevent others from landing at will.

Because no one nation is so far ahead in the missile art, it appears unlikely that such unilateral denials will ever occur. This leads some theorists to propound the theory that the moon should be considered as *res nullius* ("Free for occupation"), like the undiscovered parts of the Antarctic continent. In this way, different governments could stake out non-conflicting, peaceful claims to various parts of the moon wherever they happened to land, provided someone else hadn't gotten there first.

Long before it was applied in Antarctica, this "first come-first served" approach was the unwritten—but thoroughly understood—basis for the exploration and conquest of the New World in the 16th and 17th Centuries.

In evaluating this theory, as it is working out in the Antarctic, it must be noted that none of the claims staked out there by the various earth nations before, during or after the IGY have been recognized by any international body.

3. **Lunar national corridors**—As manned spaceships travel over the moon's crust from close-in orbits, it is possible that their navigators will lay claim to wide corridors on the moon for their home countries. They could back these claims by presenting photographs before some international "space real estate" body on earth.

If such a system comes to pass, in advance of actual landing claims, disputes might arise over conflicting claims where space-photo mapping corridors overlap later moon tractor-explored corridors.

The Antarctic overland corridor surveyed by Sir Edmund Hillary and Dr. Vivian Fuchs on their dashes to the South Pole in 1957-58 theoretically could be claimed by both New Zealand and Britain.

But what about the supply aircraft which flew over the same territory? Couldn't they claim it? Weren't some of the planes used to supply the Hillary-Fuchs Snocat team flying the American flag? Therefore a conflicting claim in theory already exists in the Antarctic. If such methods were applied to the moon, similar problems would arise.

At this writing, none of these Antarctic corridors have been recognized as sovereign to one nation. Similar moon claims may well be ignored in the same way.

4. **A United Nations concept**—The most feasible theory for future ownership of the moon is one that envisions putting our satellite under the control and jurisdiction of the United Nations. This presupposes that no staked land outposts or national corridors could be claimed by any earth nation. Rather, all of the lunar surface and its natural resources would be owned by the United Nations and leased by that body to groups of nations for peaceful exploration. The Trusteeship Council of the U.N. is the logical agency to undertake such a task, having had considerable experience with similar problems on earth.

Cooperation among the various nations during the IGY (1957-58) in the Antarctic offers some hope that similar cooperation could be undertaken on the moon. To make it work, the U.N. will have to have enough power to enforce and carry out such a mandate.

This means that the nations must give up more sovereign rights to that body than they have in the past. It applies mainly to the major world powers in the Security Council—and Red China—since the smaller powers have already given up much of their rights.

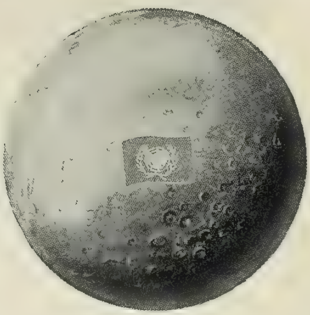
A new IGY applied to the moon, termed a "Lunar Graphical Period" (LGP) would be in order to set the framework for such an enterprise. Calling it a "period" instead of a "year" would eliminate the time-factor stigma, which has already caused a let-down among IGY scientists. It is fairly obvious that the moon is not going to be colonized in a year or eighteen months, anymore than launching small artificial earth satellites was restricted to the IGY.

• **Which concept?** Of the four concepts examined, each has its virtues and liabilities. Granting ownership of the moon to the U.N. is the most logical for the long run, but man doesn't always act by reason alone, and the result may well be a combination of the "corridor concept" and the "first-come" concept.

A titanic battle in space may be waged between the major earth powers for control of the dark side of the moon, which hasn't been discussed here. The outcome of such a battle could dictate ownership and control not only of the light side of the moon . . . but of the earth as well.

Time is short, and decisions on the ownership of our only natural satellite must be made before it is too late.

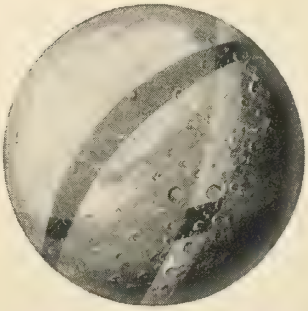
WHO OWNS THE MOON?



LOGICAL BUT difficult is to set up U.N. control of entire moon.

ONE SUGGESTION is division among the Earth nations.

SOME EXPERTS look for "first come-first served" area division.



OR THERE could develop a national corridor concept.

HOFFMAN

. . . the power behind Rocketdyne

by Erica M. Karr

WASHINGTON—Unless the Russians get there first, a Rocketdyne engine probably will put the first man on the moon—an event that could occur within six years.

In Washington this week, Rocketdyne's mild-mannered Sam Hoffman, the power behind the powerhouse of the U.S. missile effort, told the story of his company's historic record in creating the boosters for *Atlas, Thor, Jupiter* and *Redstone.*

He downplayed his own role in the company's growth from a small section in North American Aviation Co. to one of the top rocket engine producers in the country. But Sam Hoffman unquestionably had more to do with it than anyone else.

As manager of the Rocketdyne engine empire, Hoffman rules plants in Canoga Park, Calif., and Neosho, Mo., and extensive field test laboratories in California's San Susana Mountains.

• **Aircraft background**—Hoffman, 56, former university professor, joined North American as chief of the Aerophysics Department's Propulsion Section in 1949. Looking back, he says "I have spent almost my entire life in aircraft companies of one kind or another."

He has been design engineer for Fairchild Aircraft Co., Lycoming Manufacturing Co. and the Allison Division of General Motors Co. At Lycoming he was chief engineer from 1936 to 1945. Christmas, 1943, he was involved in an accident that led him out of the aviation field. He was one of two survivors of a DC-3 crack-up which killed 25 people.

"I was in and out of hospitals for six months and had plenty of time to think. The crash, I knew, would slow me up for a while. The life of a college professor looked good."

But it wasn't until two years later that he was offered a professorship of aeronautical engineering at his alma mater, Pennsylvania State University. He stayed there until North American beckoned in 1949.

• **Work on** *Navaho*—An old-time North American employee recalls that the company was "forced into the engine business—we had the prime contract for the *Navaho* and couldn't find a subcontractor who would tackle the engine for it. So we decided to build it ourselves." The only large liquid propellant engines were those that powered the *V-2*. A small team set to work disassembling the *V-2* and rebuilding it to fit the *Navaho.*

When Hoffman came to North American, its Aerophysics Department was made up of four sections: frame, guidance, nuclear and propulsion. His job as head of the propulsion department was to design and develop the rocket engine for the *Navaho* booster.

North American was charged by the Air Force with developing an air-breathing, cruise-type missile, brought up to speed and altitude by a liquid propellant rocket engine, more powerful than anything before conceived.

Work on the *Navaho* resulted in a number of steps toward achievement of the large rocket engine such as use of lightweight tubular-wall thrust chambers instead of bulky double-wall chambers. Significant advances in use of JP fuel were accomplished. Most important was the background of experience which was accumulated during the early days of development on high-thrust rocket engines.

• **In other missiles**—The engine was later repackaged and sold to Redstone Arsenal to fire the *Redstone* missile. "This is the same basic engine," Hoffman says, "which put up our first satellite." Newer and larger versions went into the *Thor, Jupiter* and *Atlas.*

The basic *Navaho* engine became the building block for a two-chambered engine in the second phase, and finally the three-engine cluster in the final phase. Its first firing in January, 1956, resulted in the highest thrust ever achieved in a ballistic missile engine. The three-barrel cluster concept of the *Navaho* had approached flight status when the Air Force program was cancelled in 1957.

The experience was accompanied by exploration in fluid dynamics, thermodynamics, chemistry and metallurgy unlike any encountered previously in the field of rocketry. An outgrowth was the development of high-performance turbopumps for forcing propellants from tanks into rocket engine chambers at high pressures. The high flow attained is sufficient to empty an average-sized swimming pool in a few minutes.

Propellant research resulted in development by Rocketdyne scientists of Hydyne, the fuel used in the Army's 1958 *Jupiter C* satellite launching. A blend of chemicals based on a derivative of hydrazine, it matched the physical properties and combustion characteristics of the alcohol fuel used in the Rocketdyne-developed *Redstone* engine which powered the first stage of the *Explorer* satellite. It gave additional thrust, with a substantial increase in vertical range.

• **New horizons**—In 1956 Rocketdyne began studies on ion propulsion. This Air Force-sponsored program will ultimately send vehicles through space by a light-giving current of charged particles a million times greater in number and weighing 350,000 times as much as the stream of electrons in a television picture tube.

In 1957 research toward a nuclear rocket engine was started at Rocketdyne under Air Force sponsorship although North American had been conducting studies in nuclear energy as early as 1946.

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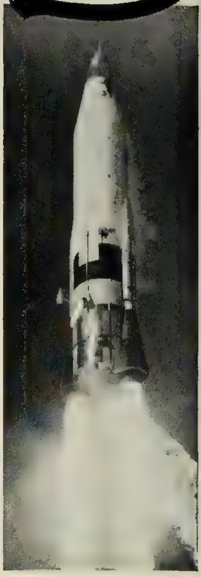
ATLAS

The myth and the missile



THE MYTH: Because he warred with Zeus, Atlas, in classical mythology, was punished by being made to support the entire world on his shoulders.

THE MISSILE: Today's Atlas ICBM bears a symbolic relationship to its classical namesake. For the future course of world events may well depend in large part on the role of the mighty Atlas. **ARMA** provides the guiding spirit for the Atlas: the inertial navigation system which guides it to its destination. Brain of the system is **ARMA**'s airborne digital computer, operational under severest conditions of vibration, temperature, noise, acceleration and deceleration. Heart of the system is **ARMA**'s inertial platform, the stable reference table from which data is fed to the computer.

ARMA also provides a comparable all-inertial guidance system for the Titan ICBM, companion-in-arms of the Atlas. **ARMA** . . . Garden City, New York. A Division of American Bosch Arma Corporation. 6416

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6416

Metals Congress Discusses Problem Solutions

Great strides reported in such fields as increasing metal strength and test methods.

LOS ANGELES—The 11th Western Metal Congress met here recently to explore a wide range of strength and fabrication problems relating to missile and rocket development. Industry representatives told how some of these problems are being solved.

Lewis E. Zwissler of Aerojet-General said that, "One of the major sources of failure in solid rocket motor cases has been the result of defeats associated with welding in the fabrication process." Zwissler, head of Aerojet's applied studies department in solid rocket research and development, said that is why so much development work is aimed at fabricating motor cases with minimum welding.

Zwissler also commented on the problem of obtaining steel strong enough for ultra-high strength pressure vessels. "Present mill practices are not adequate to give sufficient control of chemistry and cleanliness," he said. This, combined with welding drawbacks, results in lower-than-desirable motorcase quality.

• **Porosity cured**—Virtual elimination of porosity and cracking in X-200 high-silicon, high-carbon steels for skins of pressure vessels was claimed by United States Steel Corp. Porosity was eliminated, spokesmen said, by employment of a new "two-pass" technique, welding from one side on an inert gas backup. The first weld laid down filler wire of the same material as the steel involved. The second weld fused in and compacted the adjoining material. Both welds were performed with a heliarc tungsten torch.

Hughes Aircraft Co. announced development of an automatic welding process for hemispherical sections of a pressure vessel proof-stressed at a pressure creating internal wall and weld stresses approaching 87% of the metal's ultimate tensile strength. Direct current equipment and the non-consumable tungsten electrod inert gas process were used. The rejection rate due to welding alone is held below 1% in high-rate production, Hughes said.

But burst tests indicate that while many alloys can be welded and heat treated to ultra-high strength levels, many lack sufficient ductility in the weld zone area to permit practical use.

• **Testing alloys**—Solar Aircraft Co. reported testing alloys capable of heat treatment to ultimate tensile strengths in the 220,000 to 300,000 psi range. Solar said it was recognized that standard tensile and bond tests were inadequate for evaluating the potential performance of welds in pressure vessels where imposed stresses are multi-axial.

After welding parameters had been established by conventional methods and dozens of small pressure vessels were broken in tests, the conclusion was reached that each alloy has a maximum usable strength level beyond which reliability is lost.

General Electric cited its experience in fabricating vessels and tubing for nuclear applications as an example of stainless steel welding. The company uses tungsten-arc cutting of austenitic stainless steel wrought materials to prepare the 300 Series of stainless for welding. The firm notes that excellent quality cuts can be made in austenitic stainless steel, cast iron, copper and aluminum pipe by using heliarc cutting and "mechanical draftsman" units together.

• **Yield strengths**—Great emphasis was placed on increasing yield strengths of aircraft/missile metals through heat treatment and other methods and producing lighter gauges, wider widths and better flatness in structural metals.

As an example of the results of better use of existing continuous rolling facilities, Republic Steel Corp. cited Type 301 stainless steel, an austenitic grade with good work-hardening characteristics. It has been rolled on a 27-inch Sandzimer mill to .006 inch gage strip with as-rolled yield strength of over 250,000 psi. After aging, Republic says, the yield strength increased to more than 300,000 psi, with gage variation held within .0005 inch.

Douglas Aircraft engineers said 4340 ultra-high-strength aircraft steel has been heat treated to attain an ultimate tensile strength of 260,000 to 280,000 psi. Proper cleaning and plating, followed by baking and painting, will avoid hydrogen and corrosion embrittlement, they said. (Hydrogen penetration or corrosion can occur in aqueous or acid cleaning, electrolytic plating and exposure to natural atmosphere.)

Acid cleaning, which produces severely embrittling conditions, was rejected in favor of controlled plating. Adequate control involves only mild embrittlement, which can be relieved by baking. Instrumentation to achieve carbon control in heat treating processes has been considerably advanced Lindberg Engineering Co. said ". . . more R&D time is being given to problems of carbon potential control than to any other furnace problem."

• **Test methods**—New methods for non-destructive tests of materials were revealed at the Congress. Instrumentation used included radiation, ultrasonic, magnetic, various electrical devices, and eddy current testing.

Eddy currents, induced by a radio frequency field, explore the part for flaws, chemical properties and internal metallurgical dislocations. They do no damage to the part. A graph shows findings of the test.

Another recently developed method uses pulse beats in the form of echo patterns to determine metal flaws. The metal is subjected to 1000 beats per second during the test, known as "pulse echo ultrasonic flaw detection."

Both thick and thin walled casings can be inspected. Corrosion and erosion are detectable, as well as delamination in multi-layered structures.

B. F. Brown, head of physical metallurgy at the National Research Laboratory, disclosed that removal of embrittlement-causing hydrogen from steel in the molten state is practical with vacuum degassing. Brown said the process may be favored over zone refining of large solid forgings.

Coming Mid-May 1959 Second Annual

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MISSILES AND ROCKETS

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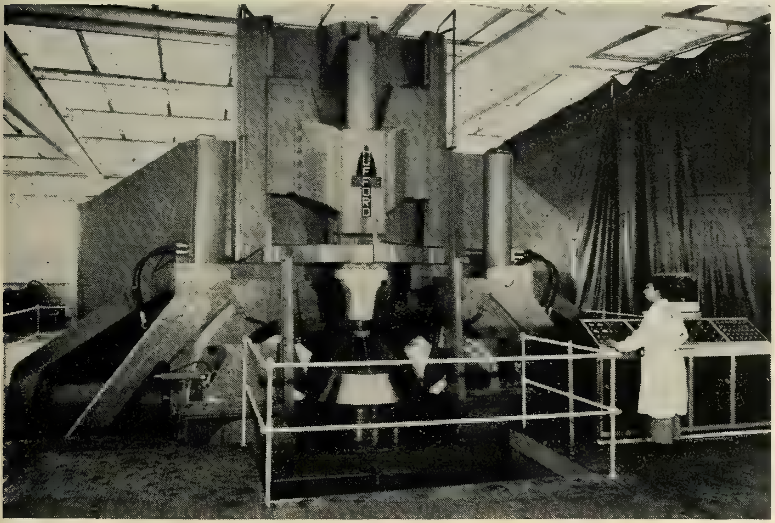
Spin Forge Forms Steel One Inch Thick



A new space age machine tool that reportedly can form a one-inch-thick piece of stainless steel or other hard metal into an aircraft or missile part has been produced by the **Siegler Corporation.**

In forming the metal part, the manufacturer says, the machine increases the strength of the material used up to 100% and the machine cuts the production cycle by more than 50% over the metal now used for making such items as rocket engine cases.

Known as the "Spin Forge," the tool is claimed to be capable of applying a total work force in excess of one million pounds to form parts up to 60 inches in diameter and 10 feet in height. The machine tool is 25 feet wide, 24 feet high, including its base, and weighs more than 450,000 pounds.

In operation the Spin Forge utilizes a combination of rolling and shearing principles to produce mechanically spun "surface-of-revolution" sections such as conical, tubular or parabolic configurations with varied wall thicknesses.

In forming a component, the metal to be formed is placed on the Spin Forge's mandrel, a form that is shaped as the desired part, and held tightly in place by a vertical tailstock or hydraulic ram that can exert 200,000 pounds of force. The mandrel is then rotated at speeds up to 400 rpm, and two massive working rollers, set across from each other at either side of the mandrel, come in to force the metal over and around the form.

Quality of finished product and shorter, lower-cost production cycles, plus elimination of a portion of the weldments normally required in the fabrication of such parts as pressure vessels or rocket engine cases, may be realized with the new tool.

- **Grain refined**—Quality of the finished engine component is achieved during the Spin Forge's roll forming through orientation and refinement of the grain of the metal. In effect, the grain is caused to flow, with the flow line and characteristics changed in such an extent that there is superior alignment. Metallurgically, the grain condition of forging is obtained with close tolerances that eliminate the need for finish machining.

A part made from 4130 steel, with the metal in fully spheroidized annealed condition, had prior to being roll-formed a tensile strength of 80,000 psi with a hardness of 90 to 96 Rockwell B. After being formed on the Spin Forge the material in the part had 160,000 psi tensile strength, grain elongation of 4-6%, and 35 to 37 Rockwell C hardness. The surface finish of a roll-formed tubular part will be approximately six micro-inches inside and 40 to 60 micro-inches outside.

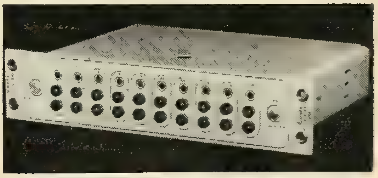
A key factor from the standpoint of both cost and finished part quality is the elimination of the longitudinal weldments and the decrease in the number of transverse welds generally associated with components made by the wrap and weld method. By eliminating major weldments in the tubular sections the Spin Forge eliminates possible points of failure.

Circle No. 225 on Subscriber Service Card.

Binary Counter Gives 100 Channel Analysis

A new transistorized 10-state indicating reversible binary counter has been announced by **Navigation Computer Corp.** The unit features both serial and parallel read-in and read-out.

Eighteen-volt dc levels are available from either side of the counter stages; and they may be directly loaded by other transistor stages. Internal amplifiers may be added to operate relays, low impedance busses, etc.



The Model 111B reversible binary counter has completely automatic internal switching. Pulses may be fed into the forward and reverse inputs, and the sum of the two inputs is made

NOTE: *For additional information about any product mentioned in this section of Missiles and Rockets use the attached prepaid reply cards. Circle numbers shown on the reply card that correspond with numbers appearing beneath items described. If no circle number accompanies the article or advertisement, give page number (and advertiser's name) on line provided at bottom of card.*

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The Editor

AMPEX:
turning point
for tape

Magnetic recording has reached the point where a better tape, by itself, can significantly improve the performance of your equipment. Anticipating this, Ampex has developed its Instrumentation Tape to assure the highest capability that the state of the art requires.

Precision tape reliability comes principally from the properties of its coating. And Ampex combines oxide preparation and careful coating techniques with the exclusive Ferro-Sheen process to produce the smoothest, most cohesive, most uniform of precision tapes. The result is measurably higher signal-to-noise ratios, and much less tape wear.

This, with its squared-up hysteresis curve, makes Ampex Instrumentation Tape ideal for all recording systems: direct, FM-carrier, PDM, and NRZ-digital.

Ampex Instrumentation Tape is available on hubs, NAB-type or die-cast magnesium - alloy Precision Reels. Widths of ¼", ½" and 1" are standard on either Mylar* or acetate base, in the following lengths, reel diameters, and base thicknesses:

AMPEX STANDARD TAPE LENGTHS (feet)

REEL DIAMETER	BASE THICKNESS (mils) 1.0	1.5
7"	1800	1250
10½"	3600	2500
14"	7200	5000

*DU PONT TRADEMARK

For complete specifications or additional tape literature, write

AMPEX
MAGNETIC TAPE
934 CHARTER STREET, REDWOOD CITY, CALIF.

Circle No. 18 on Subscriber Service Card.

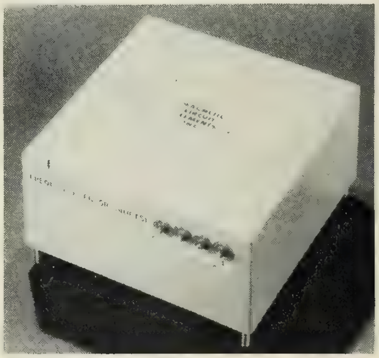
visible with neon indicators.

The units operate up to 200 KC with a single 20V supply voltage. Both push-button and electrical presetting are available and any number of units may be cascaded.

Circle No. 226 on Subscriber Service Card.

Sensor Helps Eliminate Missile Countdown Errors

A new type of frequency sensor, employing magnetic and static elements throughout, and operating on the "go, no-go" principle, has been introduced by **Magnetic Circuit Elements, Inc.**



The device, one of a family of magnetic "instrument sensors," is said to offer several important benefits over conventional dial indicators, among which are greater accuracy, reliability, reading ease and installation flexibility. Read-out is achieved by means of green and red lamps, denoting "within tolerance" or "out of tolerance" respectively.

The elimination of all movable and corrosible parts has resulted in an insensitivity to extremes of temperature and vibration, as well as to large over- and under-tolerance conditions. Tolerance limits are "built into" the sensor, enabling it to achieve accuracy of ¼% or better.

The sensor is said to make the missile countdown engineer's job much easier, since chances for reading error are, for all practical purposes, eliminated. Not only do red and green lights supplant the needle dial, but several sensors may be connected to a logic circuit in such a way that a single read-out will indicate the "no-go" condition if any one of the readings is out of tolerance.

The sensor may be mounted remotely from the read-out lamp—in wing, tail or other areas where space is not so critical as in the control area. Remote installation also minimizes danger of damage to the circuit being measured, by allowing the sensor to be mounted, for example, right next to the frequency generator.

The new unit is said to relieve the busy operator of a considerable amount of high-pressure, high-speed decision-making which, up to now, has been increasingly troublesome.

The C-400FS1 frequency sensor operates at 115 volts. Nominal frequency and tolerance limits are made to customer specifications. The 2-watt output drives 24-volt lamps or relay drives. If desired, it will work in connection with an annunciator system. Temperature limits are −65° to +185°F; vibration specifications are 20 g's; 2- to 2,000 cps.

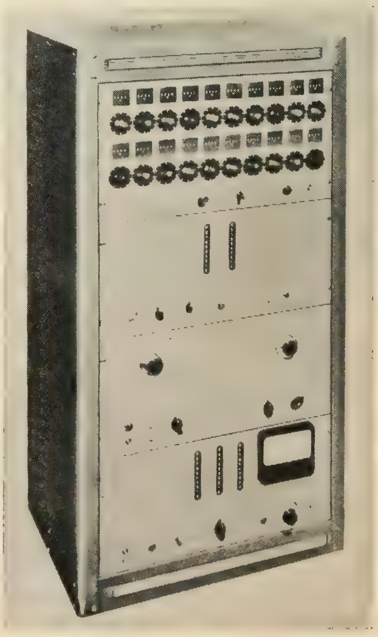
Circle No. 227 on Subscriber Service Card.

Pulse Height Analyzer Has 20-Channel Storage

A new 100-channel pulse height analyzer with 20-channel storage is announced by **The Victoreen Instrument Co.**

Designed by **Tullamore Electronics Corp.,** recently acquired subsidiary of Victoreen, the PHA-120 analyzer is the latest Tullamore instrument designed specifically for moderate and low counting rate spectroscopy work.

Because a full 100-channel analysis is made and read in five steps of 20 channels, the manufacturer claims the unit is inexpensive in addition to being precise and reliable. Other features include analog-to-digital conversion for pulse sorting which provides uniform channel widths and makes individual



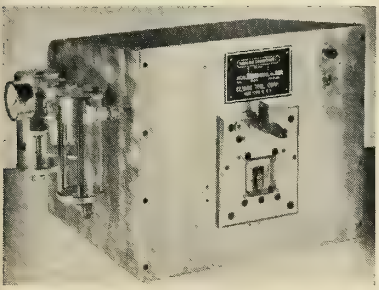
channel width adjustments unnecessary, exact alignment of end channels of 20 channel groups, no data distortion for counting rates up to 6000 cpm per channel, and "zero level" adjustment to allow a particular peak to be centered in a particular 20 channel group.

The PHA-120 analyzer comprises five basic assemblies: preamplifier, amplifier, amplitude digitizer, storage unit and decade scaler.

Circle No. 228 on Subscriber Service Card.

New Unit Straightens, Cuts, and Preforms Leads

The Electro-Machinery Division of **Design Tool Corp.,** has introduced a new radialead straightener, model AL3NS, an all-purpose machine for automatically straightening, cutting and performing the leads of transistors.



The unit straightens and aligns transistor leads, or straightens, aligns and cuts transistor leads to specific lengths, or cuts and notches to stand above the board for heat dissipation.

From a specific job, a rapid change of head will adapt the machine to serve a new job function. It will automatically straighten and align leads to the proper center distance so that the components will always exactly match the holes in the printed board.

Circle No. 229 on Subscriber Service Card.

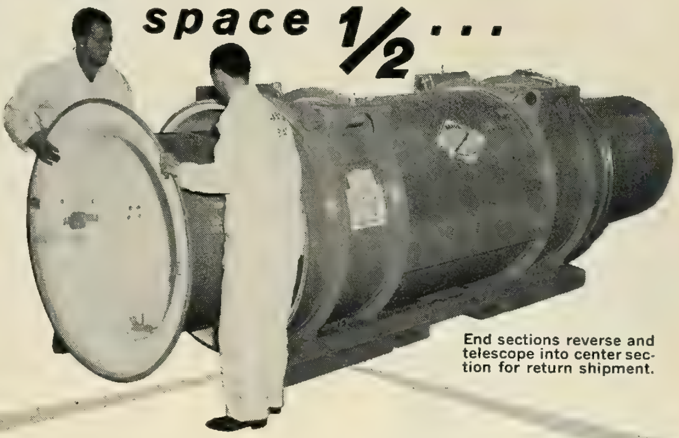
Small Synchro-Timing Motors Are Produced

The **A. W. Haydon Co.** has announced the introduction of a new line of extremely thin synchronous timing motors for 25, 50 or 60 cycle operation in five standard voltage ratings.

Main features of these motors are: thin design with available torque equivalent to much thicker motors, and completely electrical operation.

Only 7/8" thick, these motors were designed to occupy considerable less space than other available motors. Mounting dimensions conform to The A. W. Haydon Co.'s standardized di-

fiberglass
HARCO CONTAINERS
cut return shipment
space 1/2...



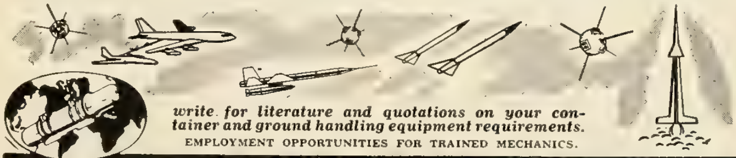
End sections reverse and telescope into center section for return shipment.

for transport, storage and ground handling of
in-flight refueling stores, missiles, rockets, jet engines and accessories

Harco Containers with integral Harco stores trailer can be return-shipped in 1/2 the space required for conventional containers.

Three steps of loading in-flight refueling stores into Harco Container; after unloading, Harco trailers are returned to container for re-use.

THE *ONLY* FIBERGLASS IN-FLIGHT REFUELING STORES CONTAINER APPROVED by BuAer, cuts 60% of weight, speeds loading and unloading of stores through unique Vee-band fastening of end sections to center section.



write for literature and quotations on your container and ground handling equipment requirements.
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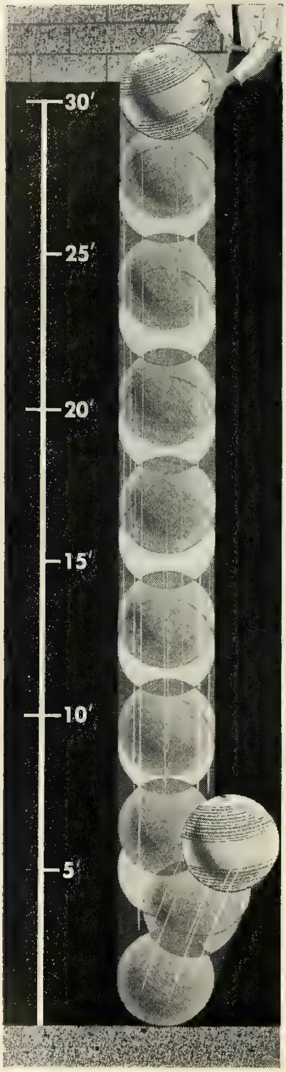
GAS OR LIQUID—STORED SAFELY IN LIGHT, SHATTERPROOF BOTTLES



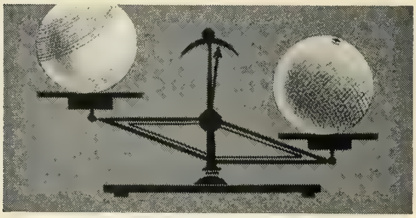
SHATTERPROOF—*Charged to 3,000 PSI, these Bendix bottles withstand a 30-foot drop to a concrete floor without damage. Absolutely no flying particles to damage personnel or equipment! Tests show even 50-caliber bullets can no more than rupture the material.*

Exceptionally light as well as safe, Bendix fibre glass bottles qualified for government and industrial applications are in mass production.

Developed originally as a high-pressure air reservoir for jet aircraft, this new type lightweight container offers exciting possibilities if you have a problem in storage of either high-pressure gas or liquid.

PROVED SUPERIORITY

Proved superior in pressurized operation on missiles and turbine-engine aircraft, Bendix light, shatterproof storage bottles by Apex are made from continuous windings of fibre glass yarn impregnated with epoxy resin. The bottles are wound on a precision machine designed to place yarn so it utilizes the greatest strength. The result is safe, non-corrosive bottles—with a temperature range from minus 65°F. to plus 200°F. and a built-in thermo-lag.



UP TO 40% SAVINGS IN WEIGHT *over steel containers for same volume and pressure.*

Operating pressures of present units vary from 3,000 to 4,500 PSI and burst pressures from 6,000 to 10,500 PSI; can be designed for other pressures as required. Most bottles are for 10,000-cycle life; bottles with shorter cycle life have been built. A variety of sizes is available.

Our Sales Engineering Department will welcome an opportunity to review your requirements for either spherical or cylindrical shaped containers and submit a proposal for your specific application.

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Bendix
AVIATION CORPORATION

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mensions for timing motors, and those of the industry in general.

The design of these motors has eliminated the need for mechanical devices to control the direction of rotation of the motor.

The 22100 series motors meet all significant requirement of specification MIL-E-5272A, and are designed for applications where high performance, reliability and immunity to rugged environments are required. Also available is a non-military version (42100 series) for high volume industrial and commercial applications.

Over 125 standard output speeds from 300 rpm down to one revolution in six hours can be supplied with either standard or heavy duty gear trains. With a nominal 30 oz-in running torque at 1 rpm, these motors can be used in a wide variety of applications.

Circle No. 230 on Subscriber Service Card.

Low Noise Amplifier Has 11 Fixed Gain Steps

A chopper-stabilized, low noise and drift amplifier, designated Model 512-A, and featuring eleven fixed gain steps with continuous variable gain between each gain setting, has been produced by the **Allegheny Instrument Co., Inc.**

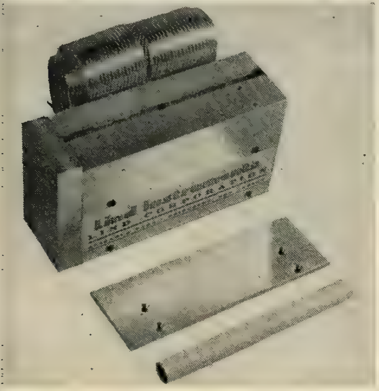
The Model 512-A is used for the amplification of signals from wire strain gage transducers, thermocouples or other low-level, low and medium output impedance signal sources. It can be used to drive pen-motors, light beam galvanometers, and cathode ray oscillographs, as well as modulators used in magnetic tape recording.

With a simple circuit change, this amplifier may be made operational or can be provided with a floating input. It is well suited for operations such as voltage summing, integration differentiation, etc.

Circle No. 231 on Subscriber Service Card.

Commutator Features Long Life, Reliability

A thermocouple and strain gauge millivolt telemetering commutator produced by **The Linde Corp.** is said to have 300 times the life and reliability of circular sampling switches.



The two pole, 60 contacts per pole switch takes only 11¼ cu. in., and weighs 12 oz. It samples 3 millivolt signals with ½% accuracy, and has contact resistance of less than 5 ohms. Redesign reduces wear by a factor of 300:1.

There are paired contacts and wipers for each channel, giving 1/60th the wear per contact, 1/5th the diameter for travel-produce, and 1/300th the wear and movement.

The commutator has a low mass system and self-cleaning, time-shared collector ring. The unit also has long motor brush life because negligible torque requirements mean low current drain by low-speed motors.

The unit will operate on 2/3rds watt power, and will operate from 36 to 2500 cps @ 25g's applied vibration, and withstanding 150 g's shock for 11 millisec.

Spiral helix provides a new approach to low-level switching. The unit is precision-machined to tolerances of ±.0001 inch. Phases to ±5%, and has a life at 10 rps in excess of 1000 hours.

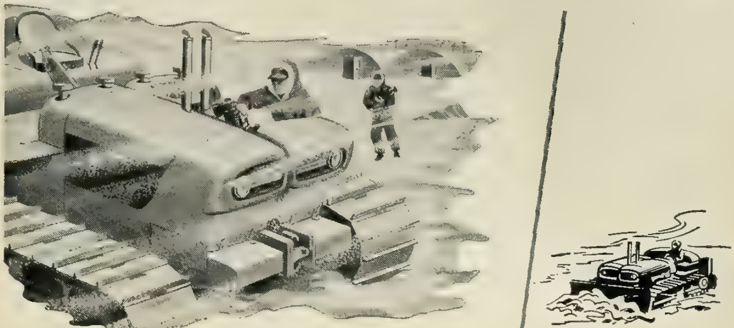
Circle No. 232 on Subscriber Service Card.

Billet Heater Features Improved Control System

A new induction billet heater which provides an improved control system for accurately heating aluminum billets to precise temperature for extrusion is offered by the High Frequency Heating Division of the **Lindberg Engineering Co.**

The "metered BTU's" system measures watt-hour input to the billet with an integrating watt-hour meter and de-

HEAT in military applications



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for spot heat
at sub-zero temperatures

Developed in coordination with Engineer Research and Development Laboratories, Ft. Belvoir, Va., Hunter Instant Lighting SPX Torches are unpowered, open-flame burners which can be lighted instantly with a match at temperatures down to –90°F. They burn any type gasoline or JP-4 fuel. Output range at variable pressures is from 15,000 to 200,000 BTU/Hour for a wide variety of sub-zero, spot heat applications — small engine starting, start-aid for bulldozers, snow plows, earthmovers, special purpose equipment, de-icing bogie wheels and tracks, heavy-duty control equipment, etc. Also available as Portable Radiant Heaters equipped with radiant burner cone and polished reflector for field heating requirements in emergency situations such as tire changing, adjusting brakes, operating mobile consoles for fire control, etc.

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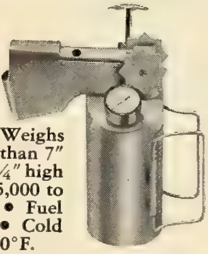
Meets field requirements for small and medium size engine starting, etc. • Weighs only 3½ lbs., less than 7" wide, 7½" long, 9¼" high • Output range 15,000 to 50,000 BTU/Hr. • Fuel capacity, 1 pint • Cold start as low as –90°F.



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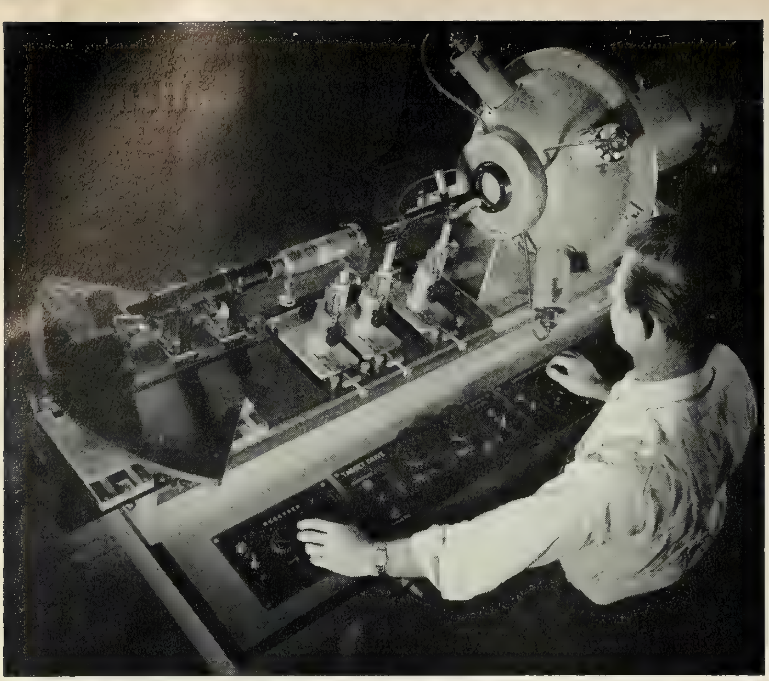

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termines, with a totalizing timer, the amount of energy absorbed by the billet. A means of compensating for the starting temperature of the billet is provided.

Thus, with a billet of known weight and known initial temperature, a predetermined amount of energy can be selected to heat the billet to the desired extrusion temperature. No prod type thermocouple (with its inherent inaccuracy and maintenance) is required.

With low-voltage power sources, stepless power control can be obtained by the use of saturable core reactors. This eliminates high contractor maintenance cost as well as providing control of the billet heating rate.

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. . . York Interview

(Continued from page 21)

"Space is a place, not a program," he said.

His understanding of the nation's space set-up is that the National Aeronautics and Space Administration has the primary role in the field. It is charged, according to Dr. York, with not only the scientific applications in space but also the overall development of the means for exploring space.

"It has the overall exploratory responsibility, and we exploit their results. There is no reason to combine these. We do not need a new booster for every communications experiment we run," he said.

Dr. York pointed out that the military has been given certain space work, but only "by exception." DOD's function, Dr. York said, is to apply the NASA projects to military needs—"We can do what amounts to putting a requirement on them."

Does this affect lead times on military space systems? Dr. York's answer was, "In principle, no." In practice, "there are a lot of people on both sides of the fence. I myself feel neutral. I mean to (a) cooperate, and (b) make the best use of the system."

Nor does Dr. York see any great problem in defining each service's role in space. The criteria is whether the space application will benefit the service's needs, and Dr. York foresees navigational satellites for Navy, communications satellites for Army, early warning satellites for the Air Force, etc.

"Anyone should be able to use space if it benefits his mission," he declares.

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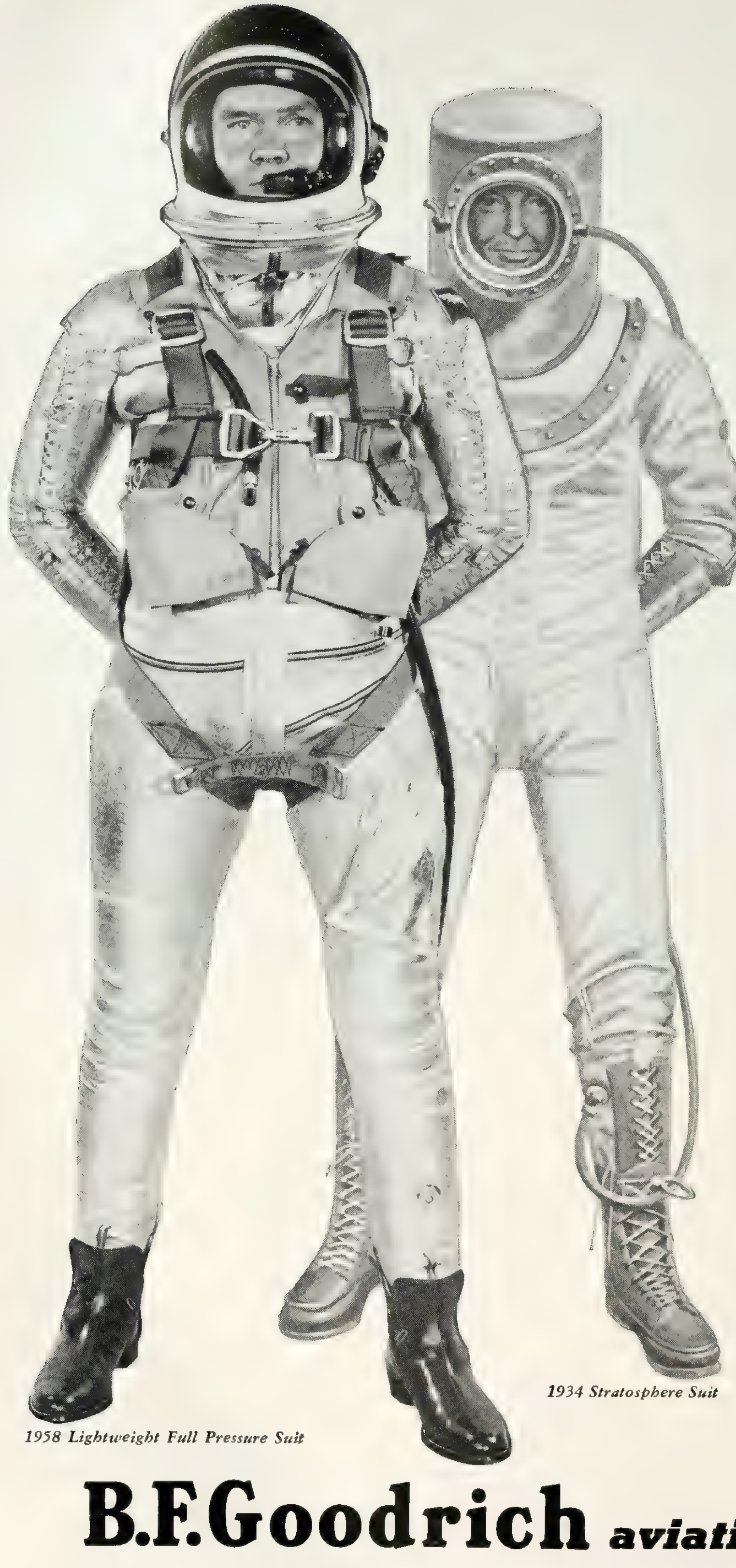

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That was the year B.F. Goodrich developed the first rubber stratosphere flying suit for attempts at setting altitude records. Through the years this suit has been constantly improved to meet the needs of higher-flying pilots. And when the first man sets foot on the moon he will probably be wearing a modification of today's B.F. Goodrich Full Pressure Suit.

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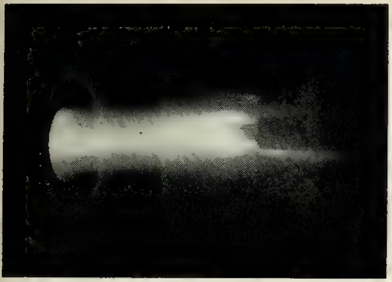


CARBON model undergoes test in plasma jet high temperature arc.

ARGMA's Plasma Jet Test Facility in Operation

Prototype model for aerodynamic heating tests reaches 50,000° Fusing argon gas with 13,000 fps flow rate

HUNTSVILLE—A new plasma-jet test facility is now in prototype operation at the Army Rocket and Guided Missile Agency here. Construction of the final version of this hyperthermal unit already has begun.

Temperatures up to a maximum of 50,000°F have been achieved with the prototype, and the final test facility, scheduled to be in operation sometime this spring, is designed for even greater capability.

The man behind this research program is Dr. Thomas A. Barr, Jr., a physicist and chief of the Magnetohydrodynamics Unit in the Agency's Ordnance Missile Laboratories Division. Dr. Barr, formerly a professor at the University of Georgia, initiated the program two years ago.

Using electric current to heat a gas, the test facility produces temperatures much higher than can be achieved through any chemical combustion process. At these temperatures, gases decompose, rather than combust. That is, following molecular breakdown, the atoms are dissociated into ions and electrons. Gases in this extreme state are referred to as plasmas.

- **Plasma-jet process**—The process for achieving such tremendous temperatures is simple in concept. The test facility consists essentially of three sections: the arc chamber, the test section, and a low-pressure chamber.

In the arc chamber are a water-cooled carbon electrode and a carbon nozzle, or ring. The electrode fits into, but does not touch, the nozzle. An external dc generator, connected between the electrode and the nozzle, provides the necessary energy to develop an electric arc in the gap between the two assemblies.

Pressurized gas introduced into the arc chamber moves through the electric arc stream and into the low-pressure area in the downstream chamber where a vacuum pump is employed. As the gas passes through the electric arc it undergoes tremendous heating, to a degree depending on the amount of electric power sent through the arc.

In the prototype, argon gas has been used principally since it is inert and has good electrical properties for conducting high currents. The gas flows through the arc in a supersonic jet, with a maximum flow rate of 13,000 feet per second. Thus the term plasma-jet test facility has developed. Characteristics of the new jet flow are regulated by adjusting the arc column, or electrode, in its position in the nozzle.

- **Material testing**—The high temperatures achieved by plasma-jet facilities are invaluable in testing materials which must withstand the extreme heat developed in missile flight—largely resulting from aerodynamic heating as a missile passes through the atmosphere.

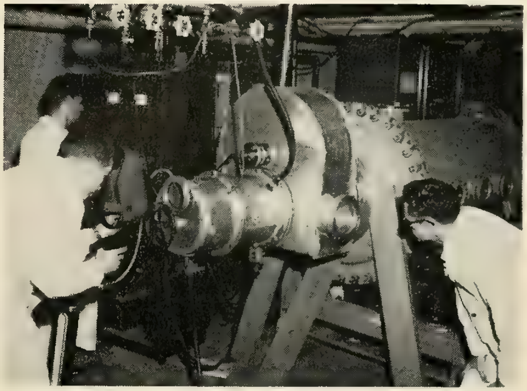
The method also is useful for testing the high-temperature properties of various gases which may be used or encountered in missile development and flight, or in simulating stellar atmospheres.

Testing conducted in the prototype has been confined largely to that related to developing the final facility, rather than any testing related to a specific missile project.

- **New facility**—Like its prototype, the final test facility now being built will be unique in both design and functions. Electric power will be provided by six generators of the type used for main propulsion in World War II destroyer escort vessels. These generators will be capable of producing up to 8 million watts of electric power as opposed to the 75,000-watt capability of the single generator now in use in the prototype.

This increase in power will make it possible to heat a much larger body of gas. A number of operations, such as the controlling of arc power and regulation of the arc column, will be ac-

IN CARBON hemisphere test, 22 kw was delivered to the arc with an ambient pressure of 0.5 cm Hg. Heat transfer to a cooled (300°K) probe was 1.0 kw/cm².



complished automatically.

Thus, the new facility will be used for aerodynamic testing as well as high-temperature testing and properly can be termed a hyperthermal wind tunnel. When completed, it will serve the testing needs of all elements of the Army Ordnance Missile Command.

• **Preliminary research**—When Dr. Barr initiated the program in 1956, he reviewed literature in the high-temperature field to determine the best method for developing the required test facility. He selected the electric arc method as the easiest for producing sustained high temperatures. He put his first arc into operation in June, 1957, and the prototype facility now in use was completed six months ago.

He has been aided in his research by three highly experienced assistants: Walter LaVaughn Hales, Thomas G. Roberts and Charles M. Cason III.

In addition to the hyperthermal wind tunnel, Dr. Barr is developing a second facility designed to produce transient high temperatures up into the millions of degrees in low-density gases.

Narmco Project

Radar Reflector Said To Sharply Cut Weight, Cost

La Mesa, Calif.—The unique design principle of Narmco Manufacturing Company's recently announced radar reflector reportedly cuts weight and costs to a fraction of that of any other current construction method for large-scale paraboloidal-reflector antennas.

Dubbed TETRAC (TEnsion TRuss Antenna Concept), the design is adaptable to antennas of from something less than 100′ to over 400′ in diameter.

The TETRAC antenna consists of nine components, basically identical in design, but size-scaled in relation to antenna dimensions. Backing for the antenna "dish" is a series of five concentric, sectional-honeycomb, sandwich compression rings, supported and stabilized by pre-stressed radial inter-ring tension rods fitted like bicycle spokes.

The other four components are honeycomb sandwich sections which form the paraboloidal reflector surface. Total number of panels varies with antenna size as does the individual panel size, but design is identical for each of the four types.

The sandwich construction panels offer high rigidity with low weight. This appears to offer a considerable advantage for solid face surfaces used with high microwave frequencies. Acceleration and deceleration inertia loads are relatively low due to inherent light weight of the honeycomb structure—an aid in maintaining close contour tolerances of reflector surface.

It is claimed that an antenna of approximately 120′ diameter would be capable of holding a surface accuracy of ±0.125 in. in a 45-mph wind. Larger antennas of about 450′ diameter can be designed to hold surface accuracy of ±0.50 in. in a 35-mph wind.

The pre-stressed construction feature also permits relatively high resonance (from 15 cps up), due to low deflection under loading conditions. As a result, forces applied to mechanical and functional components are also low. Combined with the light overall weight, the two features make it possible to simplify the antenna pedestal and other related system components—both in function and cost.

Modular construction of panels and ring sections permits an installation or move of the antenna to a remote site with a minimum of difficulty. Ring sections could be jack-assembled on the ground and easily erected into position

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in the field. Same technique might be applied to surface panels. Optical instrumentation could be used for precise alignment of components prior to erection. Rings are fitted with standoff pads for fine alignment of reflector-surface panels.

Cost-wise, the Narmco approach will vary considerably in relation to antenna size and surfacing materials used. However, it is claimed that system savings of several hundred thousand dollars can be achieved in antennas of around 100′ in diameter. The company also states that overall systems savings would be much greater in very large diameter installations.

Some work has been done on the prototype of such an antenna to be used in target tracking as part of the *Nike-Zeus* system. An additional contract is expected shortly. The company hopes also to apply the TETRAC principle to radio astronomy fields, satellite tracking, and concentration of solar energy.

Sylvania Offers Measuring Unit for Solid State Devices

WALTHAM, MASS.—Faster and more accurate orientation of silicon and germanium crystals for transistors, diodes and other semiconductor devices may be possible with a new measuring instrument developed by Sylvania Electric Products, Inc.

The company says the new instrument is superior to conventional and more complicated reflection, microscopic and X-ray methods.

Transistors have as their center a tiny die of silicon or germanium with "zones" or layers of differing electrical properties. These zones are formed by allowing or diffusing minute quantities of special metals, such as indium or antimony, into the crystal structure.

Accuracy in the formation of these zones depends on precise alignment of the die surfaces with the molecular structure of the germanium and silicon.

The Sylvania measuring device uses a converging beam of light projected upon microscope etch pits on the surface of the material. The beam is reflected from the facets of the etch pits and split into a number of component rays equal to the number of planes comprising a single pit.

The planes behave like tiny mirrors which reflect these component rays to a screen in the form of a light pattern which can be interpreted by the operator immediately as to orientation.

Proposed price for the new orientation instrument complete with accessories and power supplies is $1500 per unit.

New Amplifiers Extend Missile Tracking Range

WASHINGTON—The recent use of newly-developed low-noise parametric amplifiers is largely responsible for new records in space communications. Highly successful tests of these amplifiers were conducted independently by two distant missile-tracking stations during the space probe flight of *Pioneer IV*.

General Electric engineers, at the company's test tracking station in Schenectady, N.Y., received signals from the probe at distances of more than 410,000 miles (m/r, March 16). Allan D. French, a consulting engineer from G.E.'s Heavy Military Electronics Department, was in charge of the tracking project.

The G.E. parametric amplifier was connected between the receiving system and a horizontally-polarized 18-ft. paraboloidal-reflector antenna having a 32-db gain. Operated in the L-band (1000 mc) region, it is a straight-through

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amplifier with a pump frequency in the X-band. It uses a specially-designed parametric diode having a 1-db noise figure. The amplifier was developed by the G.E. General Engineering Laboratory.

A similar device in a system using a 14-ft. dish antenna enabled Army Ballistic Missile Agency crews at Redstone Arsenal to conduct experimental long-range tracking of *Pioneer IV*. Here, too, a parametic amplifier, developed by International Telephone and Telegraph Laboratories at Nutley, N.J., added more than 150,000 miles to the tracking-equipment range. The 13-lb space probe was tracked for a total of 37 hours to a distance of 215,000 miles before the test was discontinued.

Fred Kupersmith, test supervisor, stated that the received signal intensity, at the end of the test period, was weaker than –158 dbm. The strongest signal received was –143 dbm.

The ITT device functions much as other amplifiers, but it employs a small diffused silicon diode to produce a 90% reduction in interference resulting from static electricity and heat forces.

It was established at both stations that by employing either of the two tracking systems, without the support of its respective parametric amplifier, the faint signals would have been lost at around 50,000 miles and certainly long before the *Pioneer IV* batteries expired.

Rheem Co. and Baldwin Group Forming R&D Firm

SAN FRANCISCO, CALIF. — The Rheem Manufacturing Co. and a scientific and engineering group headed by Dr. E. M. Baldwin have announced plans to form a company for research, development and production in the field of semiconductors including silicon diodes, transistors and other devices.

Rheem will hold a majority interest in the proposed company, which will be operated as a subsidiary.

Plans call for a new plant at a site to be selected in the peninsular area south of San Francisco.

Heat Exchangers Are Used for *Atlas* and *Thor* Tests

LOS ANGELES—In-flight conversion of liquid oxygen to its gaseous state and controlled expansion of gaseous helium and nitrogen reportedly has been accomplished by a series of new heat exchangers manufactured by Waste King Corp.'s Technical Products Division here.

The heat exchangers are required to permit pressurization of liquid fuel tanks and structure during missile flights. Prototypes of the new heat exchanger are presently used on the *Atlas* and *Thor*.

The heat exchangers are made entirely of stainless steel in order to withstand the high-temperature rocket exhaust gases which are the heat source for the units.

The stainless steel design is a cylindrical shell which functions as an exhaust duct and through which a coiled tubing is passed.

The hot exhaust gases pass over the oils and convert the liquids flowing through the coils to a gas by the time they emerge at the other end of the exchanger.

Each unit is strength-tested with hydrostatic pressures up to 7500 psi

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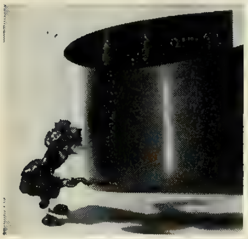
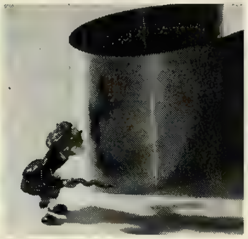
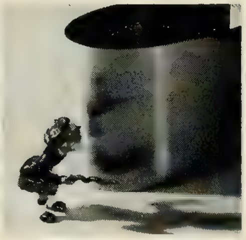


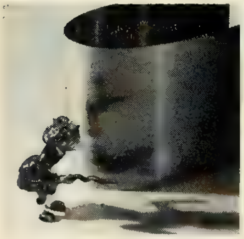
2D—A silvery white, but non-lustrous, surface produced by annealing and pickling cold reduced material. Steel sheets & strip in this condition are most ductile and the surface holds lubricant well for severe drawing operations.



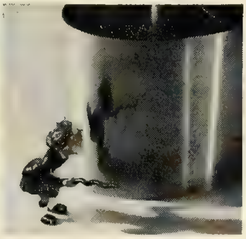
2B—Steel in the 2D condition which is subsequently rolled on a "skin pass" or temper mill. The surface acquires a bright finish from the polished rolls. This surface is somewhat more dense and hard than, 2D and is a better starting surface for later finishing and buffing operations.



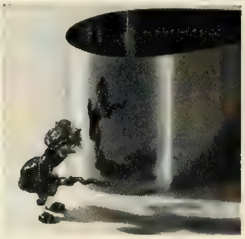
No. 3—This surface is made by grinding 2B steel with a No. 100 abrasive. This surface is smooth but not as reflective as 2B.



No. 4—A finer finish than No. 3 made by grinding 2B steel with a No. 150 abrasive Like No 3, this surface is easily blended with hand grinders after forming, drawing or welding.



No. 7—Good reflectivity and brilliance made by polishing a No. 4 surface with a No. 400 abrasive. This semi-mirror finish must be protected during fabrication by adhesive paper or strippable plastics lest the finish be marred beyond repair.



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Since No. 3, 4, 7 and 430 Bright are smooth reflective surfaces, they are not recommended for severe drawing without special precautions as the mill finish may be marred. Applications such as dairy machinery, kitchen and restaurant equipment and architectural decorative work require only local forming, so these highly polished surfaces are not greatly disturbed. All mill polished sheets are carefully packed to avoid handling imperfections. Protective adhesive paper can be specified by the buyer when needed.

For specific information on recommended surface characteristics for a particular stainless steel sheet and strip application, address your request to our Product Development Department.

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for the tubing elements and 25 psi with nitrogen for the shell structure.

The heat exchanger's operational life expectancy is rated at more than 2000 seconds.

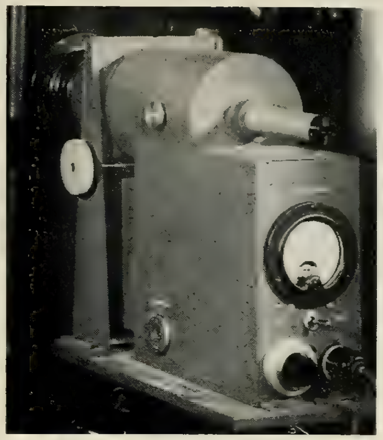
The four basic types of missile heat exchangers produced by Waste King are: for liquid oxygen only (with twin tubing coil structure); liquid oxygen and liquid nitrogen; large size liquid helium only, (with triple tubing coil structure), for booster engines; and small-size liquid helium only, used on the sustainer engine.

Avco Pyrometer Measures High Surface Temperature

WILMINGTON, MASS.—An optical recording pyrometer capable of measuring material surface temperatures between 1400°C and 3000°C with millisecond response time has been announced by Avco.

Developed by their Research and Advance Development Division here, it is called the Auto-Optic Recording Pyrometer.

Employing a high-vacuum phototube, the device focuses monochromatic light, having a wavelength of 0.65 micron, on an opaque plate. A small aperture in the plate admits the radiant energy to the phototube. After amplification of the phototube output, the final output level can be observed directly in microamperes on a built-in meter at the rear of the pyrometer.



Measuring surface changes over a 3/8-in. diameter area, sample brightness temperatures with ±20°C can be obtained.

A remote recorder can be connected to the output of the pyrometer to provide a continuous record of temperature versus time. Using a recorder, the pyrometer may be operated unattended.

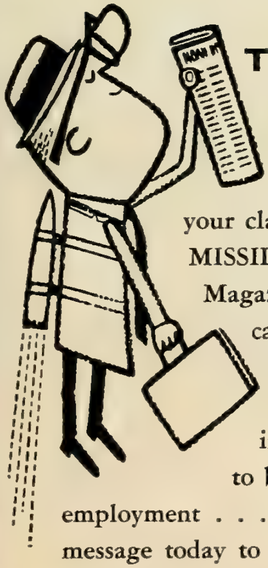
FIRETRAC System Proves Accurate Miss-measurer

FREDERICK, MD.—A highly reliable missile-tracking system for measuring "near-misses," developed here by Aerojet-General's Atlantic Division for the Navy Bureau of Aeronautics, has successfully completed recent operational evaluation tests at Point Mugu, Calif.

A *Sparrow III* air-to-air guided missile was used during the test firings at a target drone.

Designated FIRETRAC, the tracking system is essentially comprised of a four-channel receiver and standard-type telemetry transmitter, carried in a target drone, and a receiver and recorder installed in a ground station.

Four dipole antennas on the drone receive pulses from the approaching missile and the signal is automatically transmitted through a telemetering antenna to the ground recording station.



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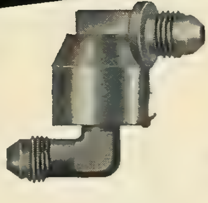

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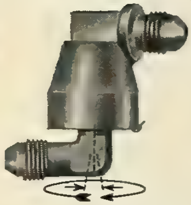

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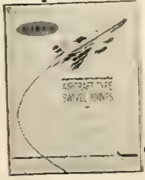

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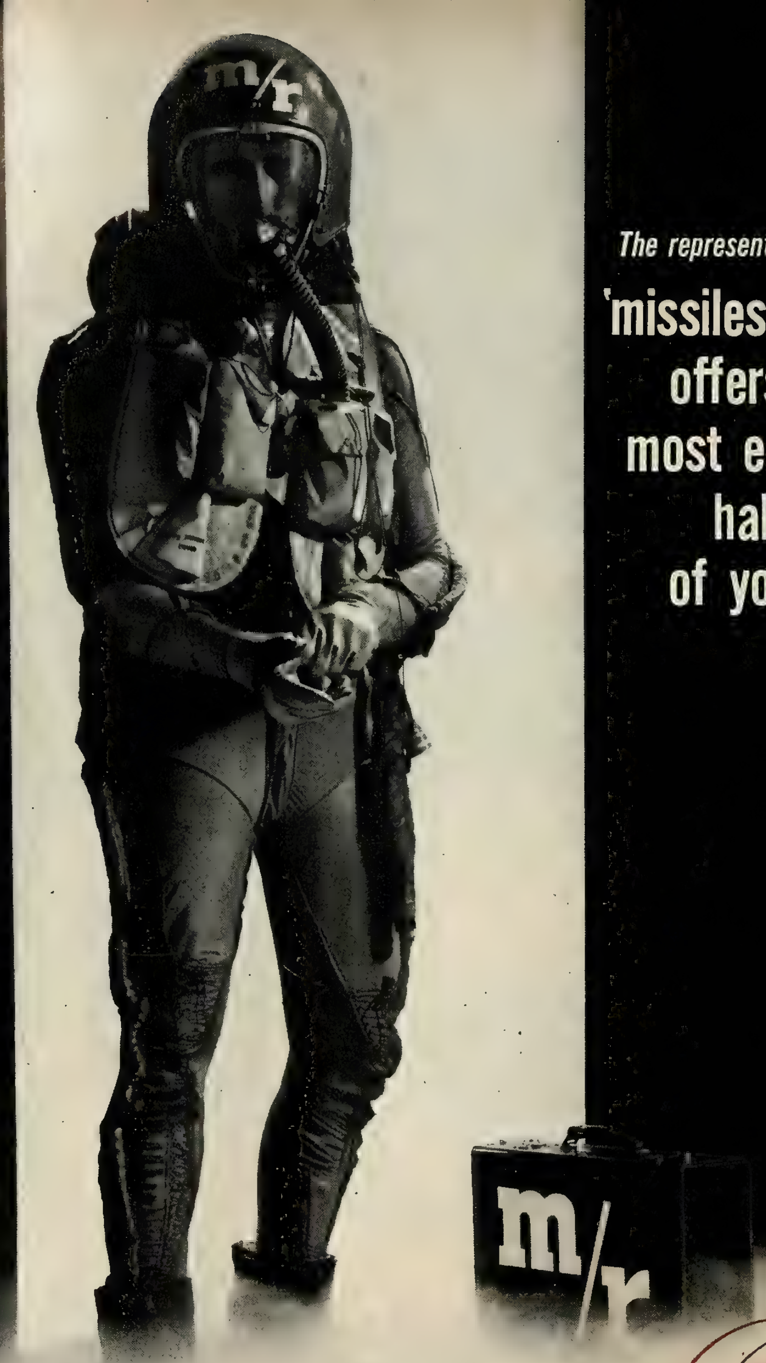

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The system utilizes phase comparison and operates in the VHF telemetry frequency band.

The system is highly sensitive within a "near-zone" of from four to five missile lengths. Within this zone, relative trajectory, velocity, and miss-distance of a missile with respect to a target drone can be computed within 5%. Until the drone is hit, any number of near-misses can be recorded intelligently as long as a finite time lag exists between missile approaches.

The ground station tape recordings provide a permanent history of all firings.

Data obtained from the FIRETRAC system could contribute to the development of better missile systems and more accurate guidance fusing subsystems.

Pioneer IV Had Ceramic Tube for High Frequency

OWENSBORO, KY.—Part of the credit for the successful tracking of *Pioneer IV* beyond 400,000 miles belongs to a small ceramic transmitting tube produced by the General Electric plant here.

The tube—a receiving type 7077, a half-inch long and a half-inch in diameter—allowed the probe to transmit with an output of 200 milliwatts at 960.05 megacycles. The higher frequency, as compared with the previously-used transistor transmitting frequencies of 108 megacycles, permits more accurate tracking.

The higher frequency signals are less subject to bending and reflection by the ionized layers of the upper atmosphere and also require less cumbersome tracking antenna.

Commerce Dept. Says Sputnik IV May Be Up

The Soviets may have orbited *Sputnik IV*.

This and other information about the Russian IGY program from Soviet and other foreign publications is contained in a Department of Commerce bulletin prepared by the Office of Technical Services.

The bulletin quotes an article appearing in *La Libre Belgique,* a Brussels newspaper, on Jan. 31, reporting that the Bochum Public Observatory in West Germany picked up radio signals on 20.5 megacycles at 7:46 on Jan. 31.

These signals, which differ from those of *Sputnik III,* were heard three times in the space of 104 minutes and always began several minutes after the signals from *Sputnik III* were heard.

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Bendix Aviation Corporation will be prime contractor for the Eagle missile—and Bendix Systems Division will quarterback the project.

Latest in a series of important defense projects to be assigned Bendix Systems, the Eagle will be a long-range, air-to-air missile designed for fleet air defense and interception missions.

Responsible for systems management and engineering in connection with the project, Bendix Systems Division will also direct the development of the Eagle missile, electronic guidance, and fire control equipment in the launching aircraft.

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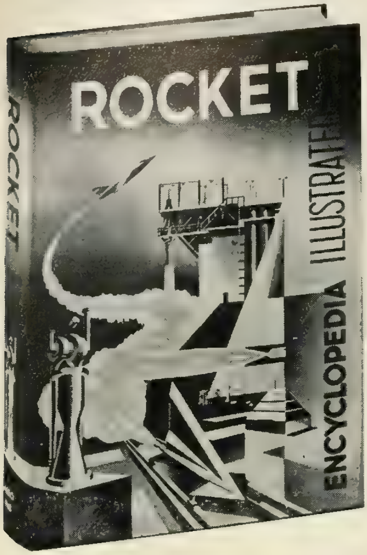

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propulsion engineering

NATO will look at propellant chemistry during a June meeting in Paris. The discussion shouldn't embarrass U.S. representatives since it is not classified. However, during NATO classified meetings on strategy or advances in weapons, our people are often lost. A major gripe: meetings are run as if each delegate had read all the papers in advance and was prepared to ask questions. NATO headquarters marks the papers "NATO Classified" before sending them to member countries. In the U.S., that means "Secret." Many times, U.S. representatives do not see the reports until they are presented, which gives little opportunity for discussion.

Navy lost its only source of one type of high-temperature gyroscope floating oil used in missiles in the Lehigh Chemical plant, Chestertown, Md., fire . . . Trouble in the USS Seawolf was not in the reactor. Shutdown was caused by leaks in the external sodium loop, not in the reactor which operated over two years without maintenance.

Titanium may be in for a comeback after more than a year of near obscurity. NASA reveals that titanium will play a leading part in McDonnell's manned space capsules. Tonnage-wise, this will not be significant. However, it can be regarded as "proof of the titanium pudding" for potential users. JPL used titanium instead of stainless steel in the final stages of the *Explorers* and *Pioneer III,* cutting weight by two pounds to permit additional instrumentation. In *Mercury,* titanium will be used as a covering and in critical spots. Major structural materials will be nickel-steel alloys. Ceramic-metal combinations probably will not be used in the capsules at all. Beryllium will be used for the re-entry heat shield.

Beryllium will be available from British sources before the year is over. Imperial Smelting is putting up a thermal reduction plant at Avonmouth. It will produce nuclear-grade beryllium for canning fuels used in high-temperature reactors. Although the company will not reveal the plant's capacity, officials say another plant will be built if British demand for beryllium reaches the almost undreamed figure of 100 tons/yr by 1965.

Red fuming nitric acid apparently has met defeat in its war of destruction. The conqueror: Compound 18007. Not too much has been said, but Precision Rubber Products, Dayton, reveals that the new material can handle all missile applications involving RFN.

More research is coming on special materials for missile and atomic energy uses. Calumet & Hecla's Wolvering Tube Division is tripling its facilities at Allen Park, Mich., to intensify studies on titanium, molybdenum, zirconium, niobium, vanadium, tantalum, and tungsten. Some of the fabrication techniques will include hot and cold extrusion, high-velocity forming and spin forming.

Retiring Atomic Energy Commissioner Willard F. Libby tells friends he hopes AEC will act on one bit of parting advice: Go more into basic high-temperature materials research needed to backup critical programs particularly in reactor projects.

Nitrogen tetroxide is now available from Hercules Powder's California plant, completed in December. N_2O_4 is being shipped in one-ton cylinders and tank cars.

The rubber vs. plastic propellant feud continues in full swing, with no hope for an early government specification which would say in effect "This is our choice." The first two stages of NASA's project *Scout* underline this. The Aerojet *Senior* is urethane; the improved Thiokol *Sergeant* is polysulfide rubber; and the scaled-up *Vanguard* third stage by ABL may feature an entirely new type of fiberglass case.

State Department no longer controls export licenses for silicon transistors. Department of Commerce has taken over licensing because of its increasing industrial use. Until recently, silicon transistors were primarily military items. They still require individual export licenses—under Bureau of Foreign Commerce's positive list, Schedule B, No. 70848—for shipment to anyplace except Canada.

missile people

The Defense Department has named **George P. Sutton** to be chief scientist of the Advanced Research Projects Agency, succeeding **Dr. Herbert York,** who has moved up to become the Pentagon's director of research and engineering.

Sutton

Sutton is a professor of aeronautical engineering at the Massachusetts Institute of Technology. Earlier, he was an engineer with the Rocketdyne Div. of North American Aviation and the Aerojet Engineering Corp. At 38, he has had 16 years' experience in rocket-missile work. He was a founder and first president of the Southern California Section of the American Rocket Society.

Dr. Hector R. Skifter has been named Assistant Director of Defense Research and Engineering, under York. He will be responsible for technical evaluation and integration of weapon systems and planning and supervision of the development of new systems. He is on leave of absence as president of Airborne Instrument Lab., Div. of Cutler-Hammer.

Ridenour

Lockheed's former chief scientist, **Dr. Louis N. Ridenour,** has been named to head its new Electronics and Avionics Division. The new division, according to the company, was set up "to further diversify operations and expand participation in the military and industrial electronics markets," and will launch Lockheed into quantity production and marketing of electromechanical products.

Ridenour was chief scientist of the U.S. Air Force in 1950 and 1951, assistant director of the Radiation Laboratory at Massachusetts Institute of Technology during World War II, and served as chairman of the U.S. Air Force Scientific Advisory Board committee that led to establishment of the Air Research and Development Command. He joined Lockheed in 1955.

Dr. D. B. Duncan, manager of advanced engineering for the Autonetics Division of North American Aviation, will serve as a member of NASA's Advisory Committee on control, guidance and navigation.

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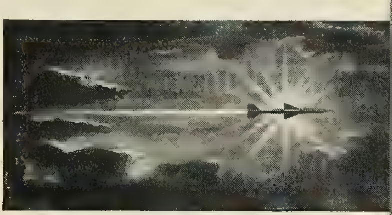

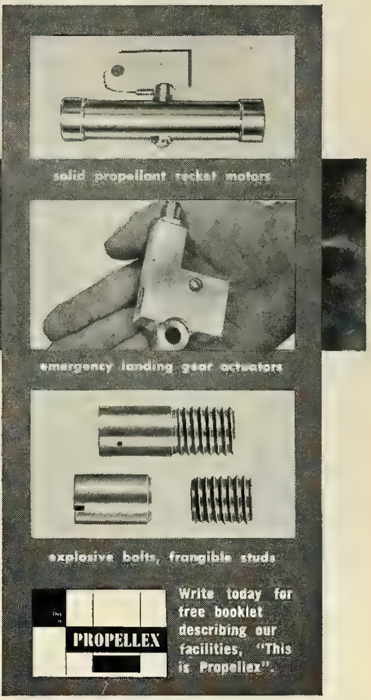
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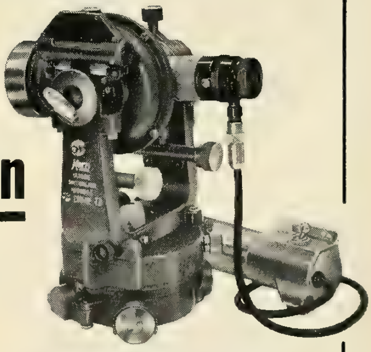

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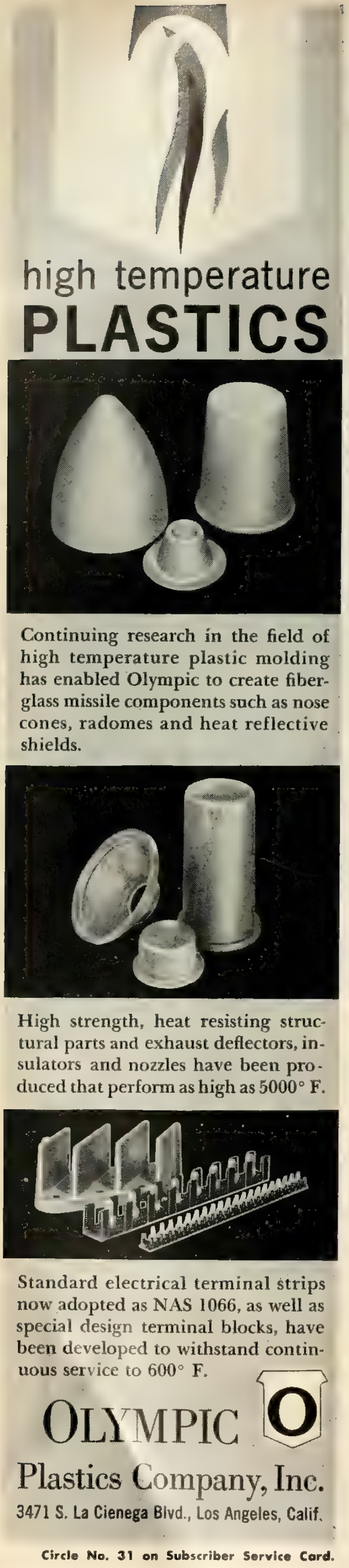

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west coast industry

By Fred S. Hunter

Among the larger West Coast companies, look for Marquardt Aircraft Corp., the ramjet producer, to be the next to change its name, removing the word "aircraft" and reducing it to Marquardt Corp. This is scheduled to take place in May. There will be others following the trend started by Whitley Collins when he decided to change Northrop Aircraft, Inc., to Northrop Corp.

We have heard that Lockheed Aircraft Corp., has discussed changing its name to more properly reflect its diversified activities, but so far as we know there has been no decision. However, the Lockheed Missile Systems Division recently changed over to Lockheed Missiles and Space Division, so you can see that they are name-conscious at Lockheed.

We rather doubt that any change is imminent at the Douglas Aircraft Co. Donald W. Douglas takes a great deal of pride in the airplanes his company has turned out over the last 35 years, and we don't think he will be in any hurry to disassociate the family name from the product it has been producing so successfully, no matter how the company may diversify.

It is also safe to predict that North American Aviation will stick to its present name. There are many companies in various fields using the "North American" name (North American Van Lines, North American Life Insurance Co., etc.), and a few years ago NAA went into court to protect its exclusive right to the name in the aviation field, winning a restraining action against a non-scheduled air carrier which had called itself North American Airlines. From a legal standpoint, it is much simpler for NAA to stay as it is.

If the directors of North American Aviation decide at the close of the year that the company's Fiscal 1959 earnings justify sweetening the regular 40¢ quarterly dividend with a year-end extra—and the way things look now, we would say this is very likely to happen—it will be paid in cash—not in stock. While NAA's dividend policy has been reasonably liberal, it has never embraced the payment of extras in stock.

Two stockholders took to the floor at the recent annual meeting to urge NAA to declare stock dividends because of the tax advantage. President J. L. Atwood replied that the directors would give consideration to such an action, but he indicated that if NAA could afford a higher dividend, the board undoubtedly would vote to make the distribution in cash. "A stock dividend is just something you already own," observed Board Chairman J. H. Kindleberger.

Marquardt Aircraft Corp. recently announced that two of its vice presidents, W. H. Schwebel and Don L. Walter, had been elected directors of the company. Generally overlooked was the fact that they have replaced two directors who had represented Olin Mathieson interests on the Marquardt Board—William C. Foster and Harry A. Sosnoski, both vice presidents of the Olin Mathieson Chemical Corp.—thus formally ending the former close affiliation between the companies.

Olin Mathieson, at one time, was Marquardt's biggest stockholder, with its holdings amounting to 25%. This distinction now belongs to the Nelson Rockefeller interests, with holdings amounting to 20%, which, it might be added, Rockefeller is retaining.

Lockheed Missiles and Space Division has developed its own airborne magnetic tape recorder to answer its need for a lightweight, versatile communication unit for scientific space missions. It says its Palo Alto research laboratory developed the recorder in one-fourth the time and one-fifth the cost asked by an outside manufacturer for the same job.

The 1959 Western Space Age Conference and Exhibit was better managed, more orderly and, we believe, more profitable to the participants than the first show held last year.

40 Nations To Be at World Flight Congress

LAS VEGAS—The United States will be staging a virtually one-nation missile and space show at the first World Congress of Flight. Russia isn't coming.

No invitation to participate was extended to the Soviet Union because reciprocal State Department travel restrictions post Nevada "off limits" to citizens of that country.

Hence, Russian scientists will miss a scheduled first public unveiling of the *Mercury* manned space capsule, showing its retro-rocket installation and pilot control monitor.

Conversely the Soviets will miss an excellent opportunity to show off some of their own space hardware to the free world. More than 40 of 77 invited nations, including Czechoslovakia which is not barred from Nevada, have signified they will send delegations to the Congress here April 12-19.

Lack of Russian representation may cloud somewhat the high aims of the conference, but not its effectiveness as a massive clearinghouse for exchange of technological information. The project is dedicated to the "belief that greater world knowledge of aircraft, missiles and spacecraft—in realistic perspective—will help bring the world closer to permanent peace."

A spokesman for the sponsoring Air Force Association said Las Vegas was picked before invitations went out in January. Proximity to the desert over which air shows will be staged, availability of nearby Nellis AFB, hotel and meeting accommodations determined the choice. "We wanted to invite the Russians, but found we couldn't because of the ground rules," AFA told m/r.

In scope, the exposition is the most ambitious undertaking of the AFA since it inaugurated Jet Age Conferences in Washington a few years ago. Executives of 1000 or more American companies, hundreds of scientists, engineers and technicians representing all components of the missile-space and aircraft industries are expected to attend.

At least 150 companies have taken exhibition space. In the international array of aircraft and space hardware will be a "walk-in" display of the 85-ft. *Atlas* ICBM. There will also be a military firepower demonstration.

Six of 11 symposiums to be conducted in the new Las Vegas auditorium, a saucer-shaped 7500-seat structure just off the gambling "Strip," will be devoted to space, missiles and R&D. They include:

—Aircraft and Space Communications sponsored by the Electronics Industries Associations. Papers will be presented by D. M. Cutler of ITT Laboratories, satellite communications; M. Berkowitz of GE, space cabin communication system design; and Stanley Plass of Packard-Bell Electronics Corp., pre-flight radiation test equipment.

—International Air Force Research sponsored by the Air Research & Development Command. Presenting papers on basic research required by military aeronautics and astronautics will be Brig. Gen. B. G. Holzman, AF office of scientific research; Col. Nathan L. Krisberg, commander of ARDC European office; Dr. B. K. Lundberg, director, aeronautical Institute of Sweden; Dr. Samuel S. Steinberg, rector, Institute Technologico de Aeronautics Sao Jose Dos Compos, Sao Paulo, Brazil; and Prof. Itiro Tani, Institute of Science & Technology, University of Tokyo.

—Missile Management, including presentations and panel discussions on weapons management, industrial problems of limited production, industry's future in space age R&D and the Prime-Sub contractor relationship.

—Advanced Air Traffic Control and Navigational Aids Concepts, including presentations on possible use of space platforms and satellite for traffic control; advanced navigational aids, such as Doppler systems, inertial guidance and hyperbolic systems, and their aircraft applications.

—Space Age, including progress reports on space exploration, presentations and discussions on the impact of science and technology on military posture and economic activity and a panel presentation on the interaction between scientific progress and man's philosophical problems and outlook.

As m/r went to press, the full program had not been completed. However, the AFA said other speakers definitely would include ARPA Director Roy Johnson, Dr. W. Randolph Lovelace, chairman of NASA's Man-In-Space Committee; Dr. Abe Silverstein, NASA director of space flight and development; Col. Carlo R. Tosti, special assistant to commander, ARDC; and Dr. Edward Teller of the University of California Radiation Laboratory.

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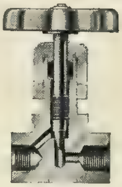

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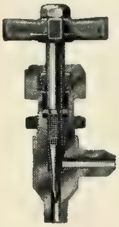

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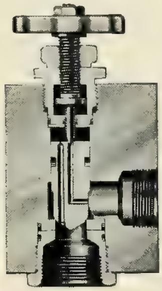

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contract awards

Boeing Airplane Co. reportedly has a government contract to study the question of placing an observatory on the moon.

George H. Stoner, general manager of Boeing's *Dyna-Soar* program, recently described the observatory as an example of the type of program Boeing is working on. Speaking in Seattle, Stoner did not identify the government agency for which the company is undertaking the studies, but he said it is many years away.

Martin has a team analyzing moon base requirements. One segment of their study was finished in August, 1957.

Other awards:

ARMY

$12,419,415—**Blount Bros. Construction Co.,** Montgomery, Ala., for construction of *Titan* and *Atlas* launch facilities and utilities at Warren AFB.

$1,455,197—**Aerojet-General Corp.,** for R&D.

$1,142,476—**Douglas Aircraft Co., Inc.,** for *Nike* repair parts and launching area items.

$714,070—**R. E. Clarson, Inc.,** St. Petersburg, Fla., for construction of Azusa facilities at Patrick AFB.

$660,230—**Warner Construction Co.,** San Angelo, Tex., for special weapons assembly facility at White Sands.

$660,000—**Telecomputing Corp.,** for overhaul of *Nike-Ajax* rate gyros and amount gyros.

$620,472—**Rocketdyne Div., North American Aviation,** for classified contracts.

$500,000—**General Electric Co., Missile and Space Vehicle Dept.,** for R&D of warhead arming and fusing system for *Little John.*

$477,883—**Chavis Construction Co., Inc.,** Pensacola, Fla., for construction of missile facilities at Eglin AFB.

$351,287—**Gilfillan Bros., Inc.,** for *Corporal* repair parts.

$296,901—**Electro-Optical Systems, Inc.,** for R&D.

$166,049—**Western Electric Co., Inc.,** for *Nike* spare parts and components.

$165,823—**Fred A. Arnold,** Los Angeles, for R.I.M. Building at Vandenberg AFB.

$143,650—**The Firestone Tire & Rubber Co.,** for *Corporal* repair parts and ground equipment.

$141,335—**Western Electric Co., Inc.,** for engineering services and training aids for improved *Nike-Hercules* system.

AIR FORCE

$18,681,124—**Sperry Gyroscope,** for radar sets, spares, data, installation and report.

$3,313,488—**Raytheon Mfg. Co.,** for electron tubes (four contracts).

$1,283,095—**Convair Div., General Dynamics,** for increase in funds (two contracts).

$725,000—**Republic Aviation Corp.,** for research.

NAVY

$3,329,797—**Packard Bell Electronics Corp.,** for integrated electronic central equipment.

book reviews

THE SCIENTIFIC REVOLUTION, edited by Gerald W. Elbers and Paul Duncan, Public Affairs Press, Washington, D.C., 275 pp., $6.00.

This book puts in print the periodic cry for drastic changes in our scientific age. In this case, the clarion call comes from 34 of the leading participants in the 1958 Yale conference on "America's Human Resources to Meet the Scientific Challenge." Each of them has contributed a chapter to the book.

While it probes varying aspects of the problem deeply, it offers few promising solutions. Agreed: we need better teachers, better courses, a better educational system that would cull the brightest students into separate classes, better understanding between scientists and the public, better use of research and development funds and more of them, and better pay for government scientists.

While varying solutions are offered, consensus seems to be that before any effective answers are possible, there must be a dramatic change in attitude on the part of the American people.

Anthropologist Margaret Mead calls for a new kind of education beginning in the nursery "which will make children not into a mass of non-scientists and a few scientists, but into citizens of a civilization in which everyone has a stake in understanding the meaning of science."

She gives examples of the mistrust some young minds entertain about the field by quoting compositions submitted by high school girls on the subject, "My Neighbor Who is a Scientist." A typical excerpt: "I wouldn't want a scientist living next door to me because anything might happen."

Another one, which has been echoed from other quarters and which scientists might well consider: "He should know how to get along with people that aren't as smart as he is."

PROGRESS IN METAL PHYSICS, edited by Prof. Bruce Chalmers of Harvard University, Pergamon Press, 408 pp, $16.

A seventh annual review of published material in the field, with selected chapters dealing with equilibrium, diffusion and imperfections in semiconductors, physical metallurgy of titanium alloys, thermodynamics and kinetics of martensitic transformations and the storage of energy in cold-worked metal.

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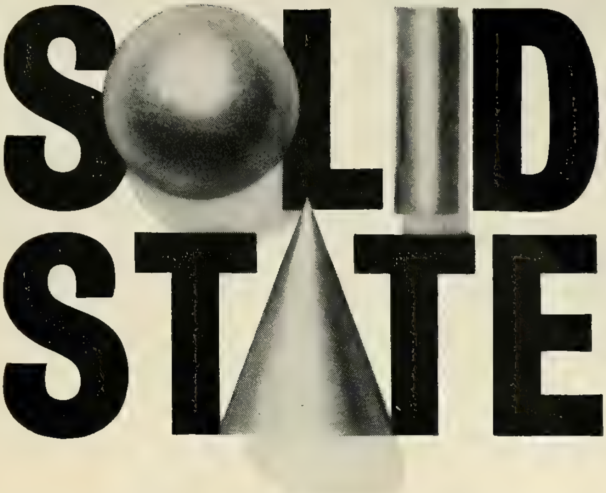

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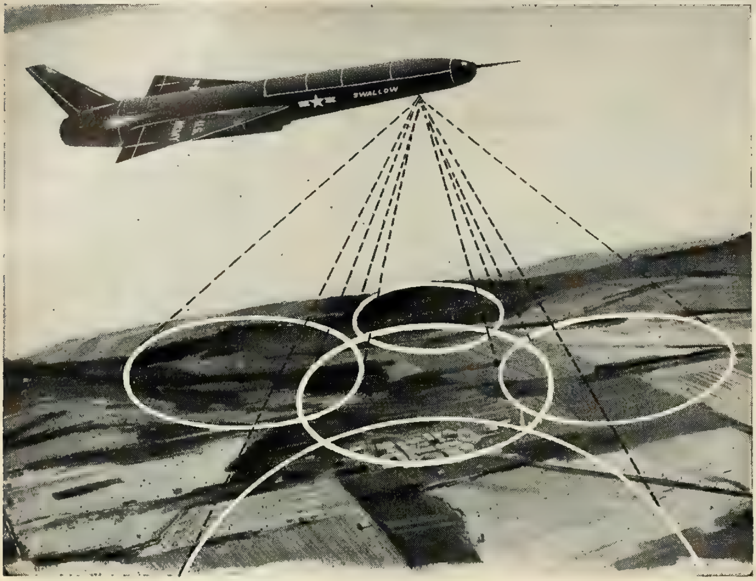

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223 Jericho Turnpike, Mineola, Long Island, New York

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MARCH

American Rocket Society, 1959 Sectional Meeting, Daytona Plaza Hotel, Daytona Beach, Fla., March 23-25.

Institute of Radio Engineers, National Convention, Coliseum and Waldorf-Astoria Hotel, New York, March 23-26.

Society of the Plastics Industry, 16th Annual Conference, Pacific Coast Section, Hotel del Coronado, San Diego, March 25-27.

American Society of Mechanical Engineers, Instruments and Regulators Division Conference, Cleveland, March 29-Apr. 2.

Society of Automotive Engineers, National Aeronautic Meeting, Hotel Commodore, New York, March 31-Apr. 3.

APRIL

Conference on Electrically Exploded Wires, sponsored by the Thermal Radiation Laboratory of the Geophysics Research Directorate of the Air Force Cambridge Research Center, Somerset Hotel, Boston, Apr. 2-3.

American Society for Quality Control, Portland Chapter, Oregon Museum of Science and Industry, Portland, Apr. 3-4.

1959 Nuclear Congress, Municipal Auditorium, Cleveland. For information: Engineers Joint Council, 29 West 39th St., New York, Apr. 5-10.

American Welding Society, 1959 Welding Show and 40th Annual Convention, International Amphitheatre and Hotel Sherman, Chicago, Apr. 7-10.

Air Force Association, World Congress of Flight, Las Vegas, Nev., Apr. 12-19.

Aeronautical Training Society, 17th Annual Meeting, Las Vegas, Apr. 16-17.

American Society of Tool Engineers, Annual Meeting, Schroeder Hotel, Milwaukee, Apr. 18-22.

American Rocket Society, Man-in-Space

(Continued next page)

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(Continued from page 52)

Conference, Hotel Chamberlain, Hampton, Va., Apr. 20-22.

Institute of Radio Engineers, Spring Technical Conference on Electronic Data Processing, Cincinnati Section, Engineering Society Bldg., Cincinnati, Apr. 21-22.

Institute of Environmental Engineers, 1959 Annual Meeting, La Salle Hotel, Chicago, Apr. 22-24.

American Rocket Society, Controllable Satellite Conference, Massachusetts Institute of Technology, Cambridge, Apr. 30-May 1.

MAY

Institute of Radio Engineers, 11th National Aeronautical Electronics Conference, Dayton, Ohio, May 4-6.

Instrument Society of America, 5th National Instrumentation Flight Test Symposium, Seattle, May 4-7.

International Scientific Radio Union, Spring Meeting, Willard Hotel, Washington, D.C., May 5-7.

1959 Electronic Components Conference, Benjamin Franklin Hotel, Philadelphia, May 6-8.

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WER AMPLIFIER. Designed to ex- d the effective range of standard emetering transmitters in the 215-260 gacycle band, the Model A-25 RF ver amplifier features miniature con- uction, stablized circuitry, and im- ved thermal characteristics. A full watt output is claimed with a 2 t input drive; input and output nomi- 50 ohms. Circuitry and sectionalized chanical construction permits full ver operation without the usual re- rement for blowers or other forced cooling. Only 42 cubic inches and pounds, the supply requirements are volts plate, 225 volts screen and er 6.3 or 12.6 ac/dc filament. The 5 is primarily designed for FM or systems, however, it is adaptable AM with slightly reduced power put. All tuning controls and monitor- test points are located on the front el so that alignment can be ac- nplished without removing the cover. A-25 is designed for operation er the usual environmental condi- s specified for missile telemetry.

le No. 240 on Subscriber Service Card.

WER SUPPLIES. A series of high age power supplies providing un- al compactness at higher currents n less ripple have been developed produced by the Condenser Prod- With a simplified circuit design, del PS15-5M60S requires input volt- of 118 VAC-60 cycles, with out- of 15 KVDC at 5.0 MA. Ripple is than 1% at full rated output. Only /16 x 3-¾ x 9 inches in height, the is hermetically sealed in an oil- d housing and is operable in tem- atures up to 85°C. Either silicon or nium rectifiers may be used in as- bly. Circuit configuration ranges n half wave to full wave doubler full wave tripler. This power sup- because of its small size, is par- larly useful in such applications as orne radar, electrostatic precipita- , infrared, irradiation and x-ray hines.

e No. 241 on Subscriber Service Card.

NTACT INSERT. A push-in con- insert designed for high-speed termination of high reliability are ng introduced by the Pyle-National With the inserts, contacts are ped automatically or semi-auto- ically to wires outside of the connector, with ample space for working and inspecting the secureness of the crimp. A cross-hold in each contact permits ready inspection of the terminiation joint to determine the depth of the wire engagement. A hand tool developed especially by Pyle-National for use with the new inserts is available for inserting the contacts into the premounted resilient insulation within the connector barrel shell. Retention ability of the resilient insulation exceeds the requirements of MIL-C-5015C, even after many reassemblies. Failures due to heating or faulty wire termination are said to have been eliminated by the crimped joint which actually is stronger than the wire itself. Push-in application of the contacts reduces the possibility of circuitry errors because contact positions are plainly identified. Should a placement error occur, it is corrected by removing the contact and relocating it in its proper position. Identified as Pyle Mod. 2 insert, the new two-piece units can be furnished with up to 100 poles for wire sizes 16, 12, or 10, with no sacrifice of environmental resistance. They can be used interchangeably with the Pyle Mod. 1 three-piece inserts within standard Pyle-Star-Line connector barrels.

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MAGNETRON. A new fixed-frequency K-band magnetron, ruggedized for missile applications, has been announced by Sylvania Electric Products Inc. The new tube, type M4154, delivers a minimum peak power output of 20 kilowatts. The tube is given a 30 g vibration test at 20 to 2000 cps, and shock tests which simulate missile conditions. The tube's adaptability to missile applications is said to have been achieved in part by cathode ruggedization, and special high pressure windows.

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SEQUENCE INDICATOR. The Opad Electric Co.'s model VA7 phase sequence indicator provides a means of rapidly determining the order in which the voltage peaks occur in a three-phase power source. This panel mounting instrument has been designed for 'built-in' applications and can be used for integration in test stands, panel boards and special equipment whose satisfactory operation is dependent upon proper phase sequence.

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MISSILE LITERATURE

CERAMICS. The Electro Motive Mfg. Co., Inc. has published a new six-page folder, describing the tough qualities of El-Menco Ceramic Disc Capacitors. The folder includes complete specifications data, charts, and graphs on the performance capabilities of the following capacitors: TS-Temperature Stable—designed for applications where a minimum capacitance change with temperature is required; SS-Semi-Stable—general purpose with stability; GP—general purpose units by bypassing, coupling or filtering applications often referred to as the "space-saving" capacitors since they provide very high capacity in relation to size; TC—Temperature Compensating—for resonant circuit applications where stability of capacitance characteristics is essential.

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COAXIAL CABLES. Full information on its line of miniature coaxial cables—both military and commercial specifications—is supplied in a 4-page catalog issued by The Rex Corp. It contains temperature-rating data for each type jacket Rex supplies, minimum tensile strength and minimum 0/0 elongation standards—to which Rex coaxial cable conductors conform, and a table covering Rex standards for miniature coaxial cables insulated with a uniform wall of extruded polytetrafluorethylene (Teflon) and shielded with a minimum of 40 microinches of silver plating on copper. Information on electrical characteristics also is included. Rex manufactures and stocks as standard items miniature coaxial cables with all types of plastic insulation which meets or exceeds all relevant military specifications and comparable commercial specifications.

Circle No. 201 on Subscriber Service Card.

GAS SERVO SYSTEM. Publication GEA-6846, 4 pages by General Electric Co., discusses the design of the system and its application to flight control surface actuation, rocket thrust vector control, or nuclear control rod actuation. Its light weight, reliability, high-temperature capability, flexible performance capabilities and energy sources are also described and illustrated.

Circle No. 202 on Subscriber Service Card.

CAPACITORS. A technical publication on what to expect from tantalum capacitors of the wet electrolytic type has just been released by Fansteel Matallurgical Corp. The 16-page booklet discusses their capabilities and limitations under various electrical and electronic service conditions and shows representative applications. In addition, the two-color publication includes tables, charts and curves.

Circle No. 203 on Subscriber Service Card.

LIQUIFIED GAS. A new six-page folder, describing a complete line of small containers for the transport and storage of liquefied gases, is available from Linde Co. Its folder includes descriptions, design features and performance data for containers ranging in capacity from 1 to 100 liters.
includes the new 25-liter aluminum
tainer, which has a special insulation
minimize evaporation losses.

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PHOTO REPRODUCTION. A new f
page illustrated folder describing
features and accessories of Keuffel
Esser Co.'s micro-master 105 mm ph
reproduction system for engineer
drawings is available for distributi
The folder describes how the mic
master system reproduces almost
size drawing, restores smudged or w
originals to almost perfect legibil
guarantees distortion-free accuracy,
by producing permanent negatives
archival quality allows economical est
lishment of a disaster storage file.
addition to a brief technical descr
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ponents, the folder explains the mic
master concept as a totally integrat
system for photographing, film proce
ing and final reproduction or projecti
printing.

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RACKS. Stone & Smith, sheet me
fabricators for the aircraft and miss
industry, has issued a brochure descr
ing the company's new line of
modular electronic racks and cabine
Seven sizes of vertical racks in heig
from 26½" plus 3" pedestal
82⅞" plus 3" pedestal in choice
depths from 22" thru 30". The catal
illustrates means of combining parts
form any given console, lists part nu
bers and gives working dimensions.

Circle No. 206 on Subscriber Service Ca

TECHNICAL DATA. McCormack Sel
Associates has published and is now
leasing their New Technical Data bo
The book will contain product specific
tions, performance data, description a
illustrations on all Mc/S/A explosi
ordnance products—explosive bolts, g
generators, pressure cartridges, ignite
squibs, initiators, destructors and oth
explosive systems and devices.

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MICRO PROBES. A literature list
micro probe research is available gra
from the Instruments Div., Philips Ele
tronics, Inc. The tabulation of publishe
papers includes 73 articles which a
pear in domestic and foreign public
tions.

Circle No. 208 on Subscriber Service Ca

COMPUTER TEXT. A new textbook
the basic principles, language a
characteristics of electronic compute
has been issued by the Radio Corp.
America. The 114-page book, entitle
"The Language and Symbology of Dig
tal Computer Systems," explains ma
of the basic characteristics of co
puters. It discusses Boolean algebra
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MAGAZINE OF WORLD ASTRONAUTICS

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THE STORY BEHIND OPERATION ARGUS
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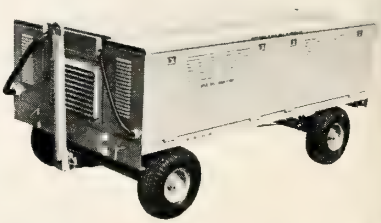

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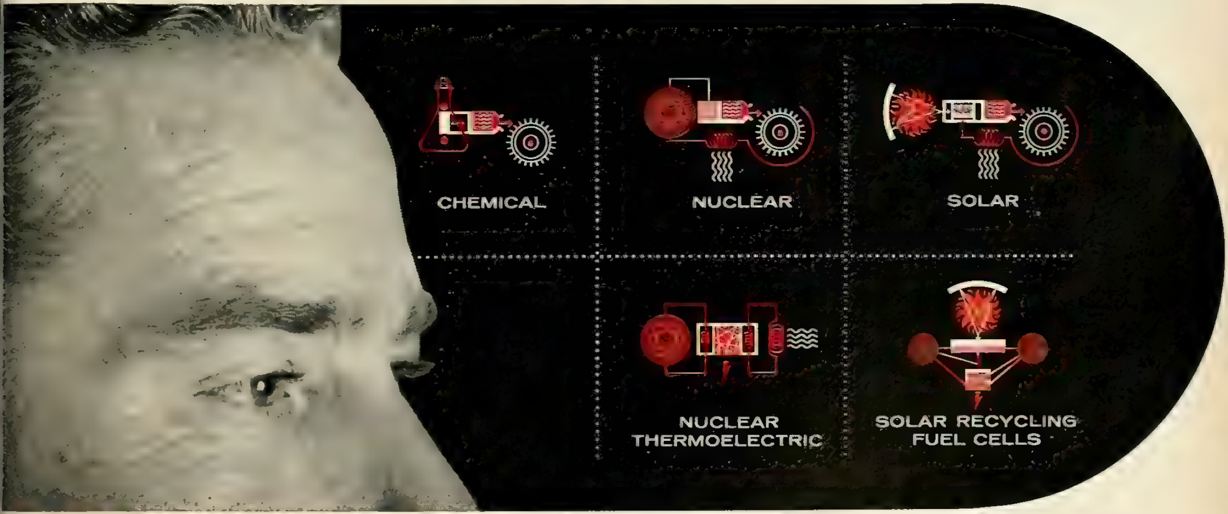

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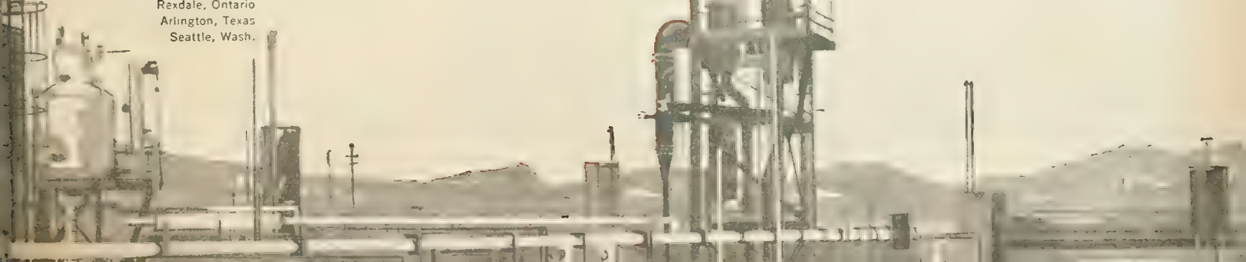

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MAGAZINE OF WORLD ASTRONAUTICS

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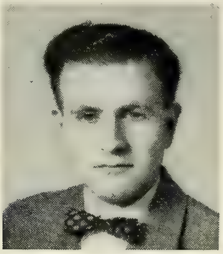

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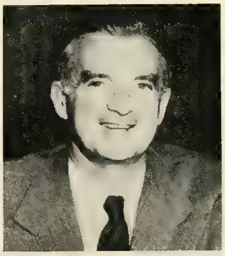
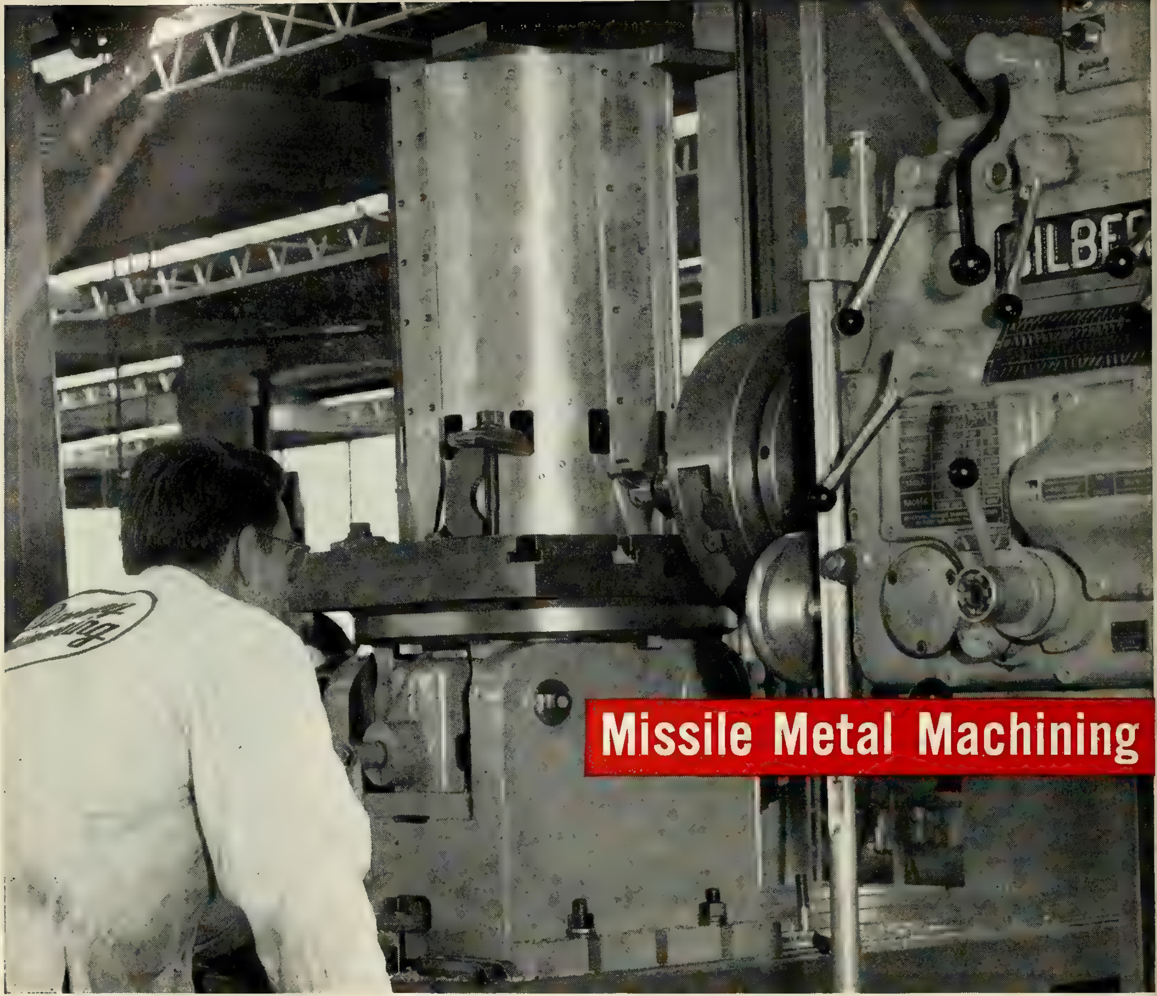


SEN. Stuart Symington, former AF secretary, criticizes administration defense policies.



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Quarles Best to Replace McElroy

Looking a little into the future we can anticipate late this summer the appointment of a new Secretary of Defense, one of the more hazardous political exercises indulged in by the White House. It is hazardous because any new man, even one who may have been on the fringes of U.S. defense business, must spend the first year just trying to encompass the tremendous scope and intricate details of that position. This leaves him for these many months at the mercy of his advisers and there is always the grave danger that he will listen to the wrong advice.

There is an old saw in the Pentagon to the effect that every time a new secretary is appointed every admiral and general drags his pet plan for saving the nation out of the bottom drawer, blows off the dust and presents it hopefully to his fresh and inexperienced audience.

In the situation coming coming up, Neil H. McElroy, the present Secretary of Defense, will return, he has announced, to his old job in industry. Sitting in the Number Two job is Deputy Secretary Donald A. Quarles, the one man who probably knows most about the U.S. defense picture in all its infinite detail.

Don Quarles started his Pentagon service on Sept. 1, 1953, as Assistant Secretary of Defense for Research and Development, a job for which his scientific training and background eminently qualified him. From there he became Secretary of the Air Force, a position he filled capably and left reluctantly to take on his present post. For years now, he has borne up under the burden of carrying out the policies of men with whom he frequently did not agree—Charles E. Wilson and McElroy.

He has done this for several reasons, the primary of which is probably his great esteem for President Eisenhower. The President asked him to take the deputy job and stay in it. Don Quarles took it and stayed. His other reasons include a strong party loyalty, a dedicated patriotism and the fact that he is convinced that he can do the job better than anyone else.

When McElroy leaves, whether it be August, September or October, the new appointee will have less than a year and a half to serve before a change of administration inexorably moves him out. He will have a year to learn the job and to make decisions on the advice of his staff. He will have a few months remaining in which he is capable of deciding and judging for himself. If he is a competent man of proven ability he probably will not want to step into such a situation. If he is a "name" chosen for political reasons, the nation can't afford him.

In either case it would mean that Deputy Secretary Quarles would be running the office to a large degree, patiently guiding again the unsure actions of a newcomer on whose decisions the survival of the United States might depend.

And somewhere in this long-drawn-out process the patience of Don Quarles may come to an end. Whether or not he was promised the top job when McElroy left, either tacitly or directly, probably very few people know. But there must be a limit to how much a man can take for either personal or party loyalty.

We suggest that Don Quarles should be named Secretary of Defense when McElroy leaves, not so much because he has earned it (which he obviously has) but because he is the best man available. We say this fully conscious of the fact that in the estimation of associates and even close friends Mr. Quarles has several characteristics—perhaps convictions is a better word—which make him less than ideal for the job.

One is over-caution. Another is his acceptance of the team (or party) decision even when he is personally convinced that the decision is wrong. However, in some quarters these are called virtues, not faults. Don Quarles has been for long periods in corporations where the team decision was unquestioned and for other periods in spots where his main job was to hold down the coattails of high-flying superiors. His devotion to the team and his caution are honestly acquired. Boldness, were boldness needed, might come from the authority of the top position.

If a new man is named Secretary of Defense and Don Quarles leaves the result will be either fearful indecision for months or dangerous chaos. The country simply cannot afford a complete change. If a new man is named and Quarles stays—he will be making the decisions anyway. Quarles has delivered selfless, devoted and competent service. He is by any yardstick best qualified. Give him the job.

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washington countdown

IN THE PENTAGON

Navy electronic guidance experts are seeking some research tips by studying techniques used by bats. Navy researchers say their studies are expected to provide a rational basis for developing mechanical and electronic analogue systems for long-range target selection and navigation.

• • •

Delayed reorganization of the Air Research Development Command will get underway within a few weeks. Naming of a successor to Lt. Gen. Samuel E. Anderson Jr. as chief of ARDC has stalled things. The Air Force now is considering the possibility of putting its big research laboratories at Wright Development Center and Cambridge under the Office of Scientific Research.

• • •

One *Polaris* submarine on station, according to operations analysis, is equivalent to an inventory of 2,000 to 4,000 deployed B-29 aircraft loaded with conventional bombs ready to make a simultaneous attack on several important targets, according to Brig. Gen. A. W. Betts.

• • •

Over 50% of the 11 missiles in the Navy's guided missile program will be operational by the end of this year, according to Rear Adm. K. S. Masterson, head of CNO's Guided Missiles Division. Operational at present are: *Sidewinder, Regulus I, Terrier, Sparrow III* and *Talos* with *Bullpup* to come later this year. Under development are *Polaris, Subroc, Tartar, Eagle* and *Corvus.*

• • •

Project *Argus* was a major topic of conversation and conflict. While it is true that certain frequencies are affected by the radioactive blanket emanating from such high altitude shots, Army R&D spokesmen insist that the frequencies utilized in the *Nike-Zeus* system are not.

ON CAPITOL HILL

The House Information Subcommittee is preparing for a showdown over the Air Force refusal to give Congress the full text of a secret survey of management of the Air Force ballistic missile program. Chairman John E. Moss (D-Calif.) said the subcommittee is "exploring in great detail alternatives to enforce the law."

Congressional pressure is mounting for greater international cooperation on space programs. Members of both the House and Senate Space Committees are urging that new attempts be made toward setting up more IGY-type projects involving both the United States and Russia.

AT NASA

Two super antennas are being modified to receive data from NASA's tentatively-scheduled Venus rockets this June. One antenna is the 60-foot telemetry dish at South Point, Hawaii. The other is the 250-foot radio telescope at Jodrell Bank, England. NASA has said launching the Venus rockets this summer depends on whether the powerful rockets and communications equipment would be available in time.

• • •

The modified feeds for the Venus shot antennas—designed and built on a crash basis in less than three months—are scheduled to be delivered shortly. The modified feed systems will enable the antennas to receive up to four simultaneous transmissions on frequencies in the 100-1000 mc range. They also will enable the antennas to send. The modified feeds will provide circular polarization on all frequencies with linear and crossed-linear on certain bands.

AROUND TOWN

Government and industry officials increasingly think materials may be the big bottleneck in future development of missiles and space ships. The National Research Council, Aircraft Industries Association and NASA are working on the problems anticipated. The National Research Council is getting out a report pinpointing some of them—and some of the possible solutions.

• • •

Dr. James Van Allen says the inner Van Allen radiation belt around the earth is a far greater threat to space travel than the outer one. Van Allen says the 1/8-inch lead shielding in *Pioneer IV* cut out almost all radiation as the moon probe flashed through the outer belt. But, he says, when the probe passed through the inner belt the probe's radiation counters acted as if the shielding weren't there.

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industry countdown

STRUCTURES

ARPA may ask industry to study another manned, maneuverable space vehicle of more "sophisticated" capability than NASA's *Mercury* project. Space Science and Technology Coordinator David A. Young of ARPA believes it could be done in about three years for $400 million. Weight would be about 20,000 lbs. with 1½ million lb. thrust engine.

• • •

Advances in glass-plastic blending for nose, exit cones and missile structures are reported by Hughes Aircraft Co. microwave laboratories. Firing test of exit cone showed 1/16 inch interior scouring with "no appreciable" efficiency loss. Material also resists salt water corrosion.

• • •

Effects of radiation upon fuels and materials will be studied in a new laboratory to be built at Middletown, Conn., with AF funds by Pratt & Whitney Aircraft Co.'s Connecticut Aircraft Nuclear Engine Laboratory.

• • •

Sounding rockets in Project *Argus* were five-stage *Argo E-5s*, 57-ft. long and weighing 7,000 lbs. Built by Aerolab Development Co., the vehicles can boost a 50 lb. instrument payload to 500 miles.

PROPULSION

Word of possible major breakthrough by Stauffer Chemical and Aerojet-General team in direct hydrogen reduction of boron is being spread by Wall Streeters. If true, cost of high energy fuels may be sharply reduced. Process also may be applied to reduction of titanium, columbium and tantalum.

• • •

$5 million NASA contract for development of 35,000 lb. *Vega* liquid second stage engine goes to General Electric Co. Engine will be modification of *Vanguard* first stage and is to have start and restart capability.

• • •

Highly-fluorinated synthetic elastomer for missile fuel cells has been developed for use at 400°F in a wide variety of corrosive chemicals. Minnesota Mining and Manufacturing Co.'s Chemical Division says the elastomer resists HEF or HiCal fuels, red fuming nitric acid and up to 90% hydrogen peroxide.

ELECTRONICS

Costs are still holding back widespread field use of advanced telemetering systems such as *Vanguard* ARRF, which automatically reduces data at 2½ times real-time rate, and Holloman AFB rocket-sled PCM system. Study is underway of "compatible" combination with new digital techniques to avoid scrapping existing analog equipment entirely.

• • •

NASA's launch this Fall of 100-ft. diameter sphere will be primary study of "passive" communications system. Radiowaves will be bounced off the aluminum vapor coating as it orbits at 1000 miles and picked up by ground receivers of ultra-high sensitivity.

• • •

Any company willing to gamble $300 million on commercial communication satellite system may expect a $30-40 million annual return. Dr. Eberhardt Rechtin, chief of JPL's guidance research division, believes system and payoff are achievable within five years.

• • •

AF *Thor-Able II* firing March 20 reportedly demonstrated the transistorized radio-inertial guidance system for *Titan* is electronically jam-proof. Bell Telephone Laboratories says the ground-placed digital computer made by Remington-Rand Univac stores trajectory data, provides steering commands in flight and calculates "exact spot" of missile impact. In latest firing, however, the AF failed to recover the *Thor-Able II* nose cone from the South Atlantic despite new instrumentation.

ASTROPHYSICS

University of Michigan astronomers are developing experiment to "shoot" the planets photoelectrically from satellite observatories. Light readings will be made over selected radiation wave lengths.

• • •

Radar contact with Venus by MIT's Lincoln Laboratory indicates the solar system is 0.0013% smaller than believed heretofore. Two hits in February, 1958, took 295.5065 seconds and 302.9842 seconds, placing Venus about 28,227,000 miles from Earth.

More Industry Items on Page 32 . . .

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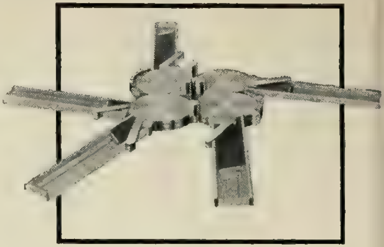

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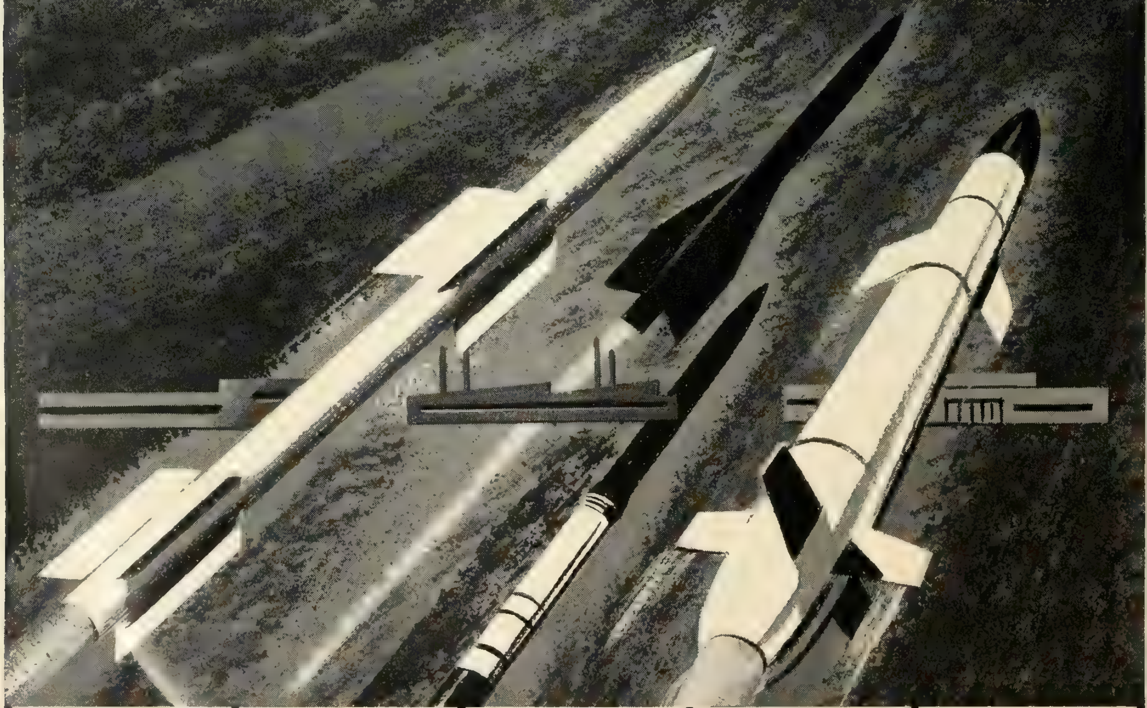

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missiles and rockets

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AOMC Recommends 'No Funds' for Missile *Able*

Only 8 Lacrosse battalions; Prototype Pershing testing soon; Chrysler submits Jupiter for target missile

by Donald E. Perry

HUNTSVILLE—About the only way Army Ordnance Missile Command can fund many desirable advanced missile projects during 1960 will be by "bootlegging" small amounts of funds from one project to another.

Reliable sources have told M/R that:

- *Missile A*—This 65-75-mile solid-propelled ballistic missile successor to the *John* family has received a "no funding" recommendation from AOMC for FY 1960. While *Missile A* has had what has often been referred to as "high priority," many persons are at loss on why such a recommendation was made by AOMC and forwarded on to the Pentagon. Some sources say, however, that a funding decision may be made after July 1.

It is known that AOMC's Ordnance Missile Laboratories on the Redstone Reservation has been selected by an evaluation committee to do as much preliminary work "in house" as is possible on *Missile A*. The committee has recommended Thiokol for the engine development and Minneapolis-Honeywell to supply the inertial guidance.

Firms who had entered the *Missile A* competition in addition to M-H included General Electric, Martin, Cornell Aeronautical Labs, Armour Research Foundation, and Douglas.

- *Mauler*—This small, easily-transported infrared homing missile for use against low-flying aircraft has the entire blessing of AOMC and an arsenal evaluation committee has reportedly picked Convair. Others in the competition are Sperry Rand, GE, Convair and Martin. With AOMC's recommendation the project is in the Pentagon for JCS review. *Mauler's* infrared system will give troops surface-to-air offense with six missiles per unit. (M/R, Nov. 17, p. 46).

A companion to *Mauler* is *Redeye*, surface-to-air bazooka, still in the feasibility study stage. It will remain in that stage as far as FY 1960 funds are concerned, M/R has been told.

- *Lacrosse*—This Martin air-to-surface, 20-mile range, terminally-guided missile will be funded for only eight battalions. However, more funds will be made available during 1960 in the development of an advanced *Lacrosse*, immune to electronic countermeasures.

AOMC has given no thought to funding of *Missile B* and *Missile C* systems, M/R has been told.

Missile D is the solid-propelled 700-mile range *Pershing* which is enjoying increased funding and will come in for even more in FY 1961. However, AOMC sources say some engineering schedules are "slipping slightly," although any lost ground will be regained when prototype testing starts on a limited scale within months.

About the Cover

Aerojet-General is using the heli-arc welding process in producing chamber assemblies for the high-thrust *Titan* rocket engine.

The thrust chambers are fabricated with hollow, tapered stainless steel tubing. The throat areas are welded first and then silver brazing is used on the skirt area to complete the chambers. These operations are used on chambers requiring special fabrication.

For production type chambers being produced in the 308,000-foot manufacturing plant, a speedier and more advanced technique of furnace brazing is being employed.

AICBM target missile—Five companies have submitted proposals. Chrysler's now is being evaluated by AOMC with the recommendation that Chrysler be permitted to go ahead with development and building of an early prototype. This probably would embrace a less expensive guidance system and storable liquids. Sources pointed out to M/R that use of *Jupiter* as an AICBM target missile can be relatively inexpensive and that early availability is assured for testing with *Nike-Zeus*. Other advanced thinking for *Jupiter* is substituting nitrogen tetroxide for LOX and switching RP for alcohol.

- *Nike-Zeus*—While many Pentagon chiefs rule out volume production of this three-stage solid rocket system now, AOMC is insisting on stepped up development work and campaigning hard for a production commitment, even if in limited quantities. Sources have told M/R that target detection is no longer a major problem with radar technology now sufficiently advanced for accurate discrimination of warhead from diversionary objects which are re-entering the atmosphere.

In *Missile A*, feasibility studies amounted to less than $100 million to each participating company. Chance-Vought carried out an unfunded study with about $6 million in its own funds for another version called *Firepower*. It is the decision that *Missile A* will employ inertial guidance rather than being a free rocket.

Highlights of IRE Convention

Transistor output to pass $350 million by 1963; sales to near $300 million.

by Charles LaFond

NEW YORK—Choosing a replica of *Vanguard I* as a symbol of this year's show, the 47th Annual IRE National Convention attracted some 60,000 electronics engineers, scientists, and manufacturers who viewed over 950 exhibits and participated in 54 technical sessions.

More than 17,000 different pieces of electronic apparatus—representing the very latest in scientific advances—were on display. The exhibition, it was announced, was the largest technical show ever staged anywhere in the world. To indicate just how big it was, a megawatt of electrical power was required to operate the displays each day.

In technical sessions at the Waldorf Astoria and the Coliseum, 275 papers were presented describing new developments in 28 branches of the art, ranging from space flight and medical electronics to stereophonic sound and air traffic safety.

• **Convention summary**—The highlight of the program was a special symposium March 24, when 10 of the nation's top authorities discussed "Future Developments in Space." Eric A. Walker, president of Pennsylvania State University, was chairman. Panel members included Lt. Gen. James M. Gavin (Ret.), vice-president of Arthur D. Little, Inc.; and Homer E. Newell, Jr., assistant director for space sciences, National Aeronautics and Space Administration. The symposium was one of three sessions on space technology.

Other events of unusual interest included a session on electronic teaching aids and another on Russian electronics technology.

The technical session program was preceded by the annual meeting of the IRE on March 23 in the Waldorf Astoria. The featured speaker was Donald B. Sinclair, vice-president of the IRE and vice-president of the General Radio Company, who spoke on "science and Coexistence."

• **Banquet**—As M/R went to press, Institute members and guests were scheduled to attend the annual banquet in the Waldorf Astoria Grand Ballroom on Wednesday evening, when the principal speaker was to be Lloyd V. Berkner, president of Associated Universities, Inc., and international president of the International Scientific Radio Union. His subject was "The IRE Enters Space." Ernest Weber, IRE president, was to announce the Institute's annual awards.

The IRE's highest technical award, the Medal of Honor, will go to E. Leon Chaffee, former director of the Cruft Laboratory, Harvard University, for "outstanding research contributions and . . . dedication to training for leadership in radio engineering."

The Morris Liebmann Memorial Prize will go jointly to Charles H. Townes, professor of physics, Columbia University, and Nicolaas Bloembergen, Gordon McKay professor of applied physics, Harvard University, "for fundamental and original contributions to the MASER."

Jack W. Herbstreit, chief of the tropospheric propagation research section, National Bureau of Standards, was named to receive the Harry Diamond Memorial Award for "original research and leadership in radiowave propagation."

The Vladimir K. Zworykin Television Prize will go to Paul Weimer, group leader of pickup tube research, RCA Laboratories, "for contributions to photoconductive-type pickup tubes."

The 1959 W.R.G. Baker Award will be given to Richard D. Thornton, assistant professor of electrical engineering, Massachusetts Institute of Technology; Franklin H. Blecher of Bell Telephone Laboratories, Inc., Murray Hill, N.J., will receive the 1959 Browder J. Thompson Memorial Prize Award.

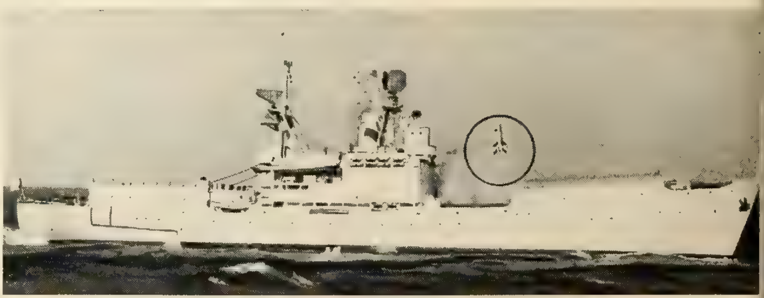
• **Recruiting**—With more jobs available than usual, the annual game of proselyting engineers got off to a slow but determined start. There were bulletin boards heavy with job lures, newspaper ads, hospitality suites, and roving raiders.

• **Transistors**—An incomparable future is foreseen for the transistor and electronic computer by leading electronics firms exhibiting at the show. The annual output is expected to approach or pass the 350-million mark by 1963—about three times the expected unit production for 1959, with sales nearing $300 million.

By 1965, combined military-commercial transistor production should reach about a half-billion units a year, with unit prices averaging "less than that of vacuum tubes," perhaps less than $1 each.

Millions of the tiny units are expected in a year or two to be the mainstay of the country's telephone networks, forming the largest application of transistor electronics on earth.

Launching of the Maruca



FRANCE'S *Maruca* surface-to-air missile (in circle) is launched from the new French missiles testing ship, the Ile d'Oléron, described as containing more electronics than any other French vessel. Newly reconverted, it once was a German transport.

Atlas Bases to be Hardened

Titan and Atlas will both be continued, Pentagon tells Congress, but Bomarc sites are cut sharply

by James Baar

WASHINGTON—The Pentagon has lisclosed it plans to face the years of he missile gap with mostly "hard" CBM bases.

It said it is considering hardening at east some of the first four "soft" above-ground bases for Convair's *Atlas*. And t said the next five *Atlas* bases—two nore than previously announced as peing planned—would be hard along vith all future ones.

However, the Air Force made clear hat it has rejected proposals to drop further work on Martin's "hard-based" *Titan* in favor of building only improved models of the *Atlas*.

The disclosures—made in closed-loor testimony before the House Defense Appropriations Subcommittee—mean the Air Force has determined the *Atlas*' radio inertial guidance system can be switched for the all-inertial guidance system originally designed for the *Titan*.

That will enable *Atlas* to be kept n heavily-protected underground bases able to withstand pressures up to 100 lbs. psi. Air Force Secretary James H. Douglas said "with the present state of the art the hardened sites are likely o withstand any attack that we foresee."

• *Atlas* **vs.** *Titan*—Douglas said the Air Force considered dropping *Titan* after receiving a Convair proposal to increase the production of an "improved" *Atlas*.

Air Force officials originally estimated a switch to only *Atlas* would save $1 billion over four years. But the estimate was reduced after further study to $400 million.

Douglas said the Air Force decided o go ahead with both *Titan* and *Atlas* because it was "unwilling to rely for our big missile program on one propulsion producer."

He said the Air Force also wants o develop a better nose cone for *Atlas* and the nose cone and advanced guidance system that are part of the *Titan* program.

• **Congressional discontent**—Subcommittee members clearly indicated discontent with administration acceptance of taking second place to Russia in ICBM armament during the missile gap.

They proposed as one possible solution a crash program to develop many more "hard" *Atlas* bases than are now planned. They proposed as another possible solution greatly increasing the manufacture of *Atlas* for use at "soft" bases—either for increasing the numbers available for a first retaliatory salvo or even a second salvo if the base survived the initial exchange in a nuclear war.

Air Force officials said the proposals already have been rejected for various reasons. But M/R has learned that Pentagon officials still are considering a Convair proposal to build six or more "hard" *Atlas* bases for a total cost of $500 to $750 million. The money is not included in the FY 1960 budget.

Other developments brought out in the hearings:

Minuteman—Boeing's *Minuteman* ICBM will be able to deliver a warhead about ¼ as heavy as one delivered by an *Atlas* and about 1/7 to 1/8 as heavy as one delivered by a *Titan*. However, the solid-propellant *Minuteman* is expected to cost only about $2 million at first and only $1 million eventually. An *Atlas* was estimated in the hearings to cost about $10 million.

Hound Dog—North American's *Hound Dog*, a turbo-jet powered air-to-surface missile, has yet to demonstrate very high reliability. *Hound Dog* is designed for firing from B-52s to destroy heavily defended targets. An extra $48 million given the Air Force last year for the program has not been used. The Air Force said the program was already moving as rapidly as possible.

Eagle—Bendix's *Eagle* will be a money-saver for the Navy. The missile will be launched by slow, inexpensive planes equipped with radar for tracking enemy planes. Supersonic speed and performance will be built into the missile—not the launching plane.

Regulus—Chance-Vought's *Regulus II* may be bought by France for the French Navy, and possibly for land bases. Navy officials said the 1200-mile range missile may possibly be shipped to France as part of the foreign military aid program.

Polaris—The Navy requested—and was denied in the President's budget—six new *Polaris* submarines and advance procurement authority for seven more. Also a total of more than $800 million was knocked out of the *Polaris* program.

Nike-Zeus—General Maxwell Taylor, Army Chief of Staff, renewed the Army's argument that the United States should go ahead with a $1 billion-a-year program to develop the *Nike-Zeus* AICBM. He admitted risks, but he said "it is the only weapon that can give us a defensive capability against the incoming missile . . . and the risks are worth taking." The subcommittee plans to look into the *Zeus* further.

Bomarc—The number of bases for the surface-to-air interceptor has been cut from 29 to 19.

Mace—Martin's *Mace* is expected to be operational this spring and delivered to U.S. forces in Europe. The Air Force will use the new tactical missile to replace eventually the *Matador*. The *Mace*—The Air Force's new tactical missile designed to deliver a nuclear warhead—also will be sent to U.S. forces in the Far East at a later date.

Pershing—The Pentagon is stepping up work on Martin's solid propellant *Pershing* to narrow the interim between the time it will be ready and the ending of production of the liquid-propelled *Redstone* that it is replacing. The Army is planning to keep the *Redstone* operational for some time, even after *Pershings* become available, and some *Redstone* may be used in the foreign military aid program.

Snark—The Air Force said its subsonic *Snark* would be fully operational this fall and the first full squadrons would be stationed by early next year. It said it decided to go ahead with the *Snark* because it was almost fully operational and it carries a large warhead. However, the *Snark* will not be further improved and the slow missile's lifetime is expected to be short. One subcommittee member said he could knock the *Snark* down with a rock.

ARS Meeting Stresses Ground Support Equipment

Pre-launch problems, data handling and missile performance comes up in technical papers delivered by specialists

by William O. Miller

DAYTONA BEACH—Ground support and handling was the theme of the first specialist meeting of the American Rocket Society—the National Flight Testing Conference—which got underway last week at this Florida resort. Specific areas discussed included ground support, countdown and prelaunch problems and data systems. Secret sessions were held on missile performance, instrumentation, flight experience and range support.

James F. Thompson of the Radio Corporation of America Service Co., Patrick AFB, was the conference chairman. Dr. John Sterner of Space Technology Laboratories was program coordinator. The speaker for the banquet held on Tuesday night was Homer J. Stewart, director of the office of program planning and evaluation of the National Aeronautics and Space Administration. Luncheon speakers were Brig. Gen. John A. Barclay, commander of the Army Ballistic Missile Agency, and Rear Adm. John T. Hayward, Assistant Chief of Naval Operations for Research and Development.

This first specialist conference of the ARS will be followed later this year by additional meetings dealing with other special areas of interest including rocket propellant thermodynamics, solid propellants and controllable satellites.

The meeting was launched with morning sessions last Monday on ground support and data systems.

More than 25 technical papers, prepared by representatives of industry, government and the military covered all phases of the broad ground support effort.

• **Cryogenic liquids**—Ground support and handling of liquid fuel missiles should be subjected to the same meticulous testing as the missile system itself, Andrew J. Pickett of ABMA, Patrick AFB, told those attending the Florida meeting.

Steady burning condition of the fuel is dependent upon the oxidizer and fuel start system providing the flow of propellant at precisely the right time and with the proper pressures, Pickett said. If they fail, the rocket engine will never attain the burning state required and result will be destruction of the missile.

Another important function of ground support equipment is to provide high-pressure gas pressurization both on the ground and aboard the missile itself, during the critical phase —usually between the start of an automatic sequence and the missile lift-off or simulated lift-off for a captive firing.

Transfer of liquid fuels and oxidizers requires special equipment and special handling techniques, Pickett said, and the evaporation problem inherent in the use of cryogenic liquids demands a replenishment system—either automatic or semi-automatic.

In conclusion, Pickett said the quality control problem probably is the cause of more ground support trouble than all other reasons combined. He urged adherence to design tolerances.

William H. Lawrence of the AF Flight Test Center, Edwards AFB, discussed operational problems with high-pressure helium, and described how helium is handled at the Missile Static Test site. Corrosive qualities of helium make it necessary to make wide use of stainless steel.

System reliability depends, said Lawrence, on a central pump station, tielines, mobile pumps and transfer trailers, in addition to reliability of individual components such as valves, fittings, and seals. Reliability of components is of utmost importance, he continued.

"We endeavor to stimulate private industry to develop better components for fixed cost purchase," he said, "and where this is not feasible we utilize a cost-plus-fixed fee development contract for prototype items to meet our specifications."

• **Experienced personnel**—Continuing the discussion of propellant handling, J. W. Schultz of Pan American World Airways, Patrick AFB, said prevention of accidents depends largely upon employment of experienced personnel, strict quality control, use of portable filters in liquid oxygen transfer, adequate maintenance of hydrocarbon fuel filters, periodic cleaning of propellant transfer equipment and inspection of protective clothing and equipment issued personnel.

• **Data systems**—The Data Systems session opened with a paper on electronic processing and analysis of high-frequency data by William C. Adams of Edwards AFB. The energy produced by the sound field of a rocket stream is greater than that produced by the direct mechanical transmission of vibration of a rocket engine, making the sound field the most important source of vibration in the missile. He said other sources of vibration include the turbulent boundary layer pressure fluctuations, oscillatory shock waves associated with nodal disturbances and sound fields produced by the turbulent wake of the missile.

E. T. Hatcher, of RCA Service Co., Patrick AFB, discussed the target acquisition data handling system for missile tracking at the Atlantic Missile Range. He said the forthcoming ballistic missile chain radar system will consist of FPS-16 instrumentation radars with 5000-mile range units located at Cape Canaveral, Grand Bahama and San Salvador Island for continuous tracking of IRBM's and ICBM's through burnout.

Though very successful, the Mod II radar chain has definite limitations for application to the new generation of pulse radars (FPS-16), especially as distance between sites is increased. Granularity probably is the most severe limitation, he said.

• **Command telemetry**—By utilizing high-speed computers on the ground and the required radio links to the missile, it might be possible to complete an entire program during a single flight. Great improvements in flight test prorams could be achieved if the data ould be analyzed in time to be useful o the purpose of the flight.

"Command Telemetry," the name hosen for this method of commanding he performance of an instrumentation ystem, was the title of the paper preented by Leonard S. Taylor of White ands Missile Range.

At another data systems session on he second day of the conference, R. . Duffin and Thomas W. Schmidt of he Office of Ordnance Research, Duram, N.C., presented a paper entitled, 'A Simple Formula for Prediction and utomatic Scrutation."

"Real Time Analysis" was discussed y Guenther Hintze, Chief of the light Simulation Laboratory at the Vhite Sands Missile Range, who called t a new approach in flight testing. He aid considerable development of beter techniques and equipment, and mooth incorporation of these into the ontinuing test programs appear to be nandatory.

New developments for faster data eduction are in progress, he said, and hould lead to processing and analyzing f flight data in real time, so that by ısing this data, some control can be xercised over the actual flight.

Duane C. Brown, RCA Service o., Patrick AFB, presented a solution o a broad class of estimation probems. A. E. Hoffmann-Heyden, of the ame company, discussed the tracking f satellites with AN/FPS-16 instrumentation radars. He reported that the *Sputnik II* C-Band echo produced an ntirely different picture than expected rom a slowly tumbling cylindrical reflector. He said it was characterized y broad intervals of high and consistent signal level over consecutive iewing sectors of about 80° and separated by a lobe structure.

The broad high-level regions, according to Hoffmann-Heyden, suggested he presence of corner or lens type reflectors as integral parts of the rocket body. *Sputnik III* carrier rocket's C-Band echoes indicated no intentional echo enhancement, he said, and this appeared logical assuming separated carrier rocket was not the object of particular tracking endeavor.

- **Countdowns**—At an afternoon session dealing with countdowns, John S. Harrison of Convair-Astronautics said experience with *Atlas* showed that countdown procedure should be established early in the design phases of the missile program to give the designers a composite operational plan.

Too often, he said, the bulk of attention is given to the technical countdown document, but success also depends on use of the countdown as a tool. Most countdown problems, he said, have resulted from human factors such as tension and confusion during countdown, breaches of discipline on intercommunications, and even overconfidence on the part of the crew members.

The *Thor* countdown system was presented by T. J. Gordon of Douglas Aircraft Co., Patrick AFB. He told the ARS members that the key to efficient countdown management is autonomy—the ability to decide on the course of action without consulting higher command.

"The command function must be centered in the blockhouse," he said.

While it is desirable to employ automatic sequencing in operational missiles, Gordon declared, manual handling of research and development launchings is desirable so that countdown crew can observe and understand what is happening as a result of their commands and vary the countdown as necessary in light of past experience.

Using *Bomarc* as the example, Herbert W. Bethel of Boeing Airplane Co. discussed the automatic countdown checkout which he said was a requisite for defensive missile systems. *Bomarc* will be placed in "ready storage" and can so remain for as long as a year with periodic checkouts.

The second period of the *Bomarc* countdown is the "warm-up period"—the first 15 minutes after an alert. During this time power is applied, gyros started, and other systems activitated.

The third period is the actual "fire-up" during which the missile receives its pre-launch commands, flight control electronics are checked over and *Bomarc* is switched to its internal power supply.

- **Missile performance**—In discussing solving of flight test problems for rocket propulsion systems, D. K. Huzel and N. D. Johnson of Rocketdyne suggested a drag cable or land line of some 100 feet during the first seconds of flight to offset lack of high-frequency response of the telemetry. He said it was estimated that up to 80% of failures occur or have their origin in the period just preceding launch and during the first few seconds of flight.

On the same subject of problems in servicing nuclear rockets, Sidney G. Rumbold, of Aerojet-General Corp., said a specific impulse of 800 seconds seems well within capabilities of the nuclear rocket as compared with about 400 seconds attainable with high-energy chemical propellants.

A challenging task in developing the nuclear rocket, Rumbold said, would be handling a single, lightweight tank 25 feet in diameter and 100 feet long, which would be used to hold the fuel. He used liquid hydrogen as an example. The use of liquid hydrogen and radiation are the basis for most of the problems anticipated, but he was confident the problems of size and radiation would be solved.

Rumbold described the representative 500,000-pound-thrust nuclear rocket as follows: reactor with a graphite core using U^{235} fissionable nuclear fuel, with a theoretical specific impulse of 720 seconds, mass ratio of 0.75, take-off weight 250,000 pounds, tank diameter 25 feet, and overall length 126 feet.

C. M. Wedertz of Douglas Aircraft discussed the missile handling equipment for flight test programs, using *Thor* as an example. He pointed out that special equipment was needed because *Thor* is relatively thin-skinned and certain portions of the missile must be maintained in a controlled environment. Lighter, more transportable ground equipment now is in production to make *Thor* independent of climate or urban facilities.

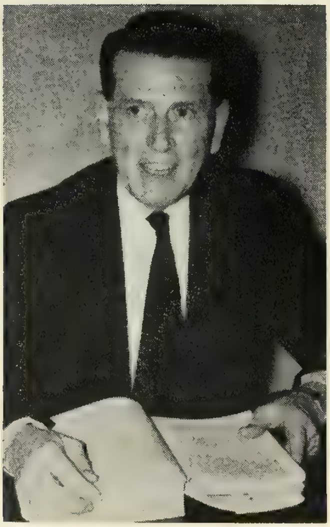
New GSE for Nike

QUARTERMASTER Corps' "Ranger," all-purpose vehicle is being used to lift *Nike-Hercules* to its launching rack for union with the booster. It can pull 19,000 lbs. and lift 10,000 lbs.

an m/r exclusive:

U.S. Survival in the Atomic/Missile Age

Rep. James G. FULTON



REP. FULTON (R-Pa.), a ranking Republican member of the House Science and Astronautics Committee and the House Foreign Affairs Committee, is serving his eighth term in Congress, and has made the defense and space posture of the nation one of his major fields of inquiry.

Big Nation power plays today are as fast as a big league baseball game. A crack of the bat, or a line drive down center field, and the strategic positions of the teams change, and the stands are electrified. Few people get hurt either in the stands or on the field, but it is certainly interesting and attracts the white flooding light of publicity and solid support of the fans.

Underneath, the owners and backers are playing a deadly serious game. No team can win all the time, but if any group or team is unsuccessful too long they may lose the ball park as well as the team and fans.

The two big league powers, USA and USSR, are and have been winning and losing ball games for the last twelve years. But it is still a tight series and no one has a really decisive advantage. Both powers have their own ball parks, teams on the field, and plenty of interest—excitement from the nations in their own bleachers as well as the uncommitted nations in the general admission seats. Anybody who tries to give the results of this world series during the tight twelfth game is permitting his bravery to get beyond his reason.

Neither the USSR nor USA has such overwhelming strength that it can eliminate the other. Each has sufficient current strength in various fields so that neither could destroy the other without being nearly destroyed itself, which is clearly unprofitable. The best proof of this is the military stalemate that has existed since 1948, when the USA and the Free World first began its military and economic buildup with the Marshall plan, NATO, etc.

So, does the argument of who is ahead in the ICBM race really profit us? In the missile and rocket field each nation surpasses the other in different ways, but neither one presently has an effective strategic superiority.

We have no information that the Soviets have operational ICBM weapon capability, nor do we know that there has been a successful target re-entry by a Soviet ICBM in which the CEP (circle of probable error) has been accurate enough to indicate that it is at this date even a partially successful military weaponry system. I challenge anybody to prove otherwise.

Statements giving the USSR this capability are pure guess work. Of course, the Soviets have their IRBM land range, and their southwest-to-northeast ICBM land range, largely over Siberia. But successful missile flights of the length that the USA has completed over the Atlantic missile range from Cape Canaveral to Ascension Island, would fall in the Pacific Ocean on Russia's ICBM range. Their range is too short for land fall, and there is no evidence of successful Russian ICBM sea re-entry shots, such as this country has publicly announced.

Foreign policy commitments must be sustained in a lawless world with equally extensive military and economic strength. The Soviets have a big army, massive artillery and tanks, plus a large and rapidly obsolescent submarine fleet which could be of little use in a missile nuclear war.

The best that critics of the administration's ICBM

(See FULTON page 38)

wo eminent lawmakers write their own widely divergent views
n the Russian threat and how the U.S. should counter it

Sen. Stuart
SYMINGTON

SEN. SYMINGTON (D-Mo.), a Democratic member of the Senate Aeronautical and Space Sciences Committee and the Senate Armed Services Committee, is serving his second term in the Senate, and was previously Secretary of the Air Force in the Truman Administration.

There are many experts on past wars, but none on future wars. As Gen. Maxwell D. Taylor, Chief of Staff of the U.S. Army, testified: "In my judgment, any dogmatic prediction of what will take place after an initial nuclear exchange is beyond the human capability."

Let us hope there will never be any real experts on nuclear wars, not on the grounds that no one would survive to become an expert, but on the premise that we may have the courage and the wisdom to prevent such destruction from ever getting started.

It is not enough, however, for us to be comforted by such hope. We must also be prepared for the dreadful alternative. In fact, such preparedness may well be the only sound basis upon which the hope for peace may grow.

Many sincere and informed people have varying judgments as to what constitutes adequate preparedness or adequate defense. Such differences are understandable. But there are certain propositions upon which, in my judgment, there should be substantial agreement. They are:

If a nuclear war does happen, it will come with such suddenness and destruction that there will be no time to defend or retaliate with any strength except that already in existence. Neither weapons on the drawing boards nor those whose production was postponed will have any effect upon the outcome of the conflict.

Since the time factor for response to an attack may be but a matter of minutes, the state of readiness of our weapons is of crucial importance. Those forces not so alert may be no asset; in fact, they may turn out to have been an actual handicap as a pre-attack source of unwarranted complacency.

It is wrong to measure our retaliatory strength in terms of what we have available before an attack has occurred. Our strength should be judged on what we believe we would have left, and could use, after attack.

With the premise that we would not be the aggressor, this nation must have substantially more retaliatory strength, or substantially better dispersed and protected retaliatory strength, than the pre-attack strength of the attacker.

The Communists are building up their strategic strike capability at a faster rate than we are. Therefore, obviously our relative position is deteriorating. Under such circumstances, some day in the near future we may well find ourselves with a post-attack capability insufficient to meet the requirements either of deterrence or of adequate retaliation.

The capability for swift retaliatory delivery of nuclear weapons has great significance in international negotiations and also in the imposition of control over others without the use of the weapons as such. This power is often referred to in terms of "nuclear blackmail."

It is a matter of U.S. policy, not lack of U.S. economic strength, which has allowed the Russians to develop and produce strategic striking power at a greater rate than

(See SYMINGTON page 39)

Industry Tells Congress:

Do More Basic Propulsion Research Now

by William E. Howard

WASHINGTON—Industry experts have told Congress the timetable for U.S. space exploration hinges largely upon an immediate stepup in industrial basic research to reveal the factors—chiefly cost—which ultimately will determine the choice of propulsion systems.

A concerted effort now to produce more basic knowledge to indicate which chemical, nuclear and electrical systems should be pushed to production was viewed as possibly shaving years and millions of dollars from engineering missions to the moon and planets. It could result in a harder timetable than the present generalized "5 to 10 years."

Soundings by the House Committee on Science and Astronautics produced urgent recommendations to:

- Greatly expand liquid and solid fuel research. Witnesses said more chemists should be put to work synthesizing high-energy compounds and developing storables and hypergolics needed for maneuvering and stopping and starting in space.

There is an "immediate need" for comprehensive development of operational capacity with a highly reliable system for upper rocket stages using liquid hydrogen and liquid oxygen or liquid fluorine. High cryogenic engine applied research should be expanded.

- Build larger liquid-fueled engines. Six-million-lb.-thrust capacity and higher is required to launch moon and Mars vehicles.

To make these engines economically feasible, development of recoverable boosters should be pushed along with reduction in hardware weight and development of cheaper, expendable "production" models.

Former Navy Secretary Dan A. Kimball, now president of Aerojet-General Corp., said improvements in boosters alone might save up to $1 million a shot, providing a more expensive recoverable booster could be re-used a half-dozen times or more.

- Initiate at once an industrial program, apart from AEC research, to develop a usable test nuclear-powered vehicle. No accurate cost estimates appear possible otherwise for producing a nuclear rocket because of the enormous and still unexplored problems involved in heat transfer and radiation hazard, if used as a first stage or for manned flight.

In this connection, another Aerojet-General witness said work is progressing there on a hydrogen propulsion reactor which appears feasible "in a considerably shorter time scale than *Rover* and for considerably less money since it uses already-developed gas cooled reactors." The system does no have the (4500°F) temperature problem of *Rover*, nor ion gun problems.

However, T. F. Dixon, chief engineer of North American Aviation' Rocketdyne Division which is workin on *Rover*, said the project is movin ahead. He said it could be speeded u by hiking the present $20 million-a year funding to $40 million.

Nuclear thrust/weight advantag more than doubling the best expecte chemical specific impulse of 450 seconds, several witnesses agreed, make i the most likely interplanetary vehicl once development problems are licked

• Russia ahead—While there is n supporting evidence, the committee wa told it is a "safe assumption" tha Soviet scientists are in front in the rac to produce electrical propulsion systems. Aerojet-General witnesses said fo this reason the U.S. program shoul be boosted. They said a flyable electrical propulsion system may be attainable in five years, possibly three.

Although the hearings were bille as mostly "educational" for the 2 freshmen committee members, industr recommendations elicited some quic reaction.

• Basic research bills—Rep. Jame G. Fulton (R-Pa.) filed legislation t give NASA and the National Scienc Foundation what would amount to "blank check" to back "overall research" of fuels and propulsion systems. Fulton specified development o chemical, ion, photon and solar propulsion.

Rep. Emilio Q. Daddario (D Conn.) pledged efforts to get mor money for the *Rover* nuclear rocket And Committee Chairman Overto Brooks (D-La.) said he would pus his bill to add a flat 10% for basi research to all R&D contracts ove $100,000.

Asked by Brooks how he felt abou the bill, Dr. H. W. Ritchey, vice-president and director of the rockets divisio of Thiokol Chemical Corp., said: "Ma we stand up and cheer?"

First Photo of Hound Dog

TRAINING and test model of North American GAM-77 *Hound Dog* rests on its pylon under wing of B-52. Test vehicle will have same aerodynamic characteristics as the operational bird.

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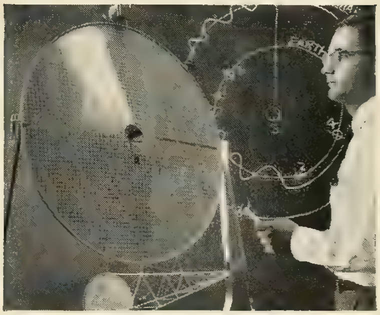
Test of ballistic missile propulsion system. Other tests cover space vehicle control units.



1/20th scale model of unmanned Martian reconnaissance vehicle, a Boeing study project.

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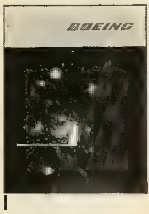

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The AF Space Medicine Chief

Dr. Hubertus Strughold looks beyond Project Mercury to time when space flights may last months; emphasizes that long-range medical research must be pressed now

Q: **Dr. Strughold, I suppose you are familiar with Project *Mercury*—that is, the plan recently announced by the National Aeronautics and Space Administration, to send a man into orbit—are you personally involved?**

A: Naturally, I am familiar with it; however, if you ask, am I associated with it, the answer is, "No." If you mean, does it lie within my sphere of interest, I would reply, "Yes, it does." In fact, I worked along such lines.

Q: **To put a man in space?**

A: Let us say, rather, to create an artificial environment with which it is possible to put a man in space, an environment in a capsule.

Q: **Didn't you suggest to the research council of the School of Aviation Medicine at Randolph AFB that an experimental space cabin should be provided for research in this respect?**

A: Yes, in 1953. It was immediately approved and was delivered in 1954. Since that time, we have been conducting studies of the requirements for a man-in-space capsule—first for just a few hours, then for 24 hours, later for seven days and longer. That was the cabin in which Airman Donald Farrell spent a week about a year ago.

Q: **Weren't there some comments that the real space flight situation can't be studied in such an earth-bound experimental cabin?**

A: Of course it cannot. Actually it is not the purpose of such an experimental chamber to simulate all the conditions encountered in space flight. We cannot produce for instance the state of dynamic weightlessness, certain radiations and certain psychological factors.

Q: **What do you actually study?**

A: It is the purpose of a space cabin simulator—as we call this chamber—to test a sealed cabin equipped with air regenerating devices as to its capability to keep a man alive and alert over a longer period of time. More in detail we study the best kind of artificial atmosphere, the best pattern of day-night cycle, the psychology of isolation and confinement. Our aim is to attain an optimum of comfort, a maximum of efficiency of the air regenerating and controlling devices and a minimum concerning their volume and weight in terms of economic logistics.

Q: **Isn't there a great deal of duplication in space medicine research or bioastronautics? As you know, the word "duplication" always comes up in the hearings conducted by the special space committees of the Senate and the House.**

A: Duplication is a waste of money, of course, and should be avoided. But this word must not be confused with "overlapping." There are always at different places and sometimes at the same place different aspects about the same thing; different methods of approach. This is necessary to get a complete picture of the problem and to get the solution faster. I think overlapping in every kind of research is sound and should not be avoided.

Q: **Returning to NASA's Project *Mercury*, how do the experiments in your space cabin simulator fit into the picture of this project?**

A: With Project *Mercury* we are now entering the engineering phase of the man-in-space program to build such a system into a capsule which can be fitted on a booster rocket as the nose cone or terminal stage. The same is of course the case with the cabin of the *X-15* and that of the *Dyna-Soar* type of vehicle.

Q: **Have you medical people cooperated with the engineers?**

A: In our medical research, we always consult with the engineers, taking into consideration their practical limitations—for example, the size and weight of the system, using present booster vehicles. Similarly, they have consulted with us in designing cabins for the various vehicles.

Photo by William Vandivert, TIME Inc.

"BUBBLES," hangs in F94C cockpit in weightless state during flight by Dr. Siegried Gerathewohol.

Q: **Then you don't believe that your work is done? That everything we need to know about man in space is now known?**

A: On the contrary, there are many areas in which we require much more information. For example, the radiation belt around the Earth, discovered last year by Dr. James A. Van Allen. We must learn its precise boundaries, its type and intensity and origin, so that we can learn to protect the pilot from too much exposure as he passes through it. Perhaps we must avoid it. The discovery of this radiation belt is perhaps the most important one in geophysics during the past 50 years. And we should all be proud that this was done with U.S. satellites.

Q: **Could there be other dangerous conditions in space that are still unknown?**

A: There could be. Just as Van Allen's radiation belt was unknown, until the *Explorer* satellites revealed it.

Q: **So there is still a great deal of basic medical research to be done on—and in—space?**

A: Definitely, yes.

Q: **Going beyond the first orbital flights in the *Mercury* capsule?**

A: Far beyond those flights. My understanding is that the *Mercury* satellite will attain a maximum altitude of approximately 150 miles. It will carry only one man. After several circuits of the earth, it will descend into the atmosphere again, and will be lowered by parachute to the ground, or to the ocean, where it will be recovered.

Q: **That is the flight plan proposed by NASA?**

A: Yes, and now we must prepare to place very much larger vehicles in orbit, carrying two or more men. We must look forward to satellites at much greater altitudes—with lifetimes of days, weeks and months. We have to prepare for flights to the moon and the other planets. All these projects require medical experiments before the engineers will be ready to go ahead with them.

Q: **Are you carrying on such experiments at the School of Aviation Medicine?**

A: Indeed we are. My colleagues in the Division of Space Medicine—Col. Paul Campbell, its chief, Lt. Col. George Steinkamp and Lt. Col. David Simons are among them—have a number of such experiments under way, and others planned. In a few months, we will move into our new laboratories at Brooks AFB in San Antonio. There we will have, for example, a space cabin—or capsule—for two men. We will be able to examine their psychological effects upon each other, to cite an example.

Again, we make studies of metabolic rhythms—day-night cycles—in preparation for extended flights in space, where there are no natural alternations for day and night. The use of green water plants—algae—in a closed ecological system, such as a space vehicle on a long voyage to Mars, is one of our projects.

Q: **The purpose of the plants is to renew the cabin air?**

A: Yes. To absorb carbon dioxide and supply fresh oxygen, by photosynthesis. Also we continue to study the functional effects of weightlessness.

Q: **How about acceleration and deceleration, during takeoff and re-entry? The capsule doesn't take care of these problems?**

A: Only to a limited degree, by cushioning the effects somewhat.

Q: **Is there a possibility that the pilot will black out from the tremendous g forces at those times?**

A: We must do everything to avoid this. At the time of launching, and again on re-entry in this type of capsule, the pilot will be in a supine position—on his back. In that position, he can take a greater number of g's than if he were sitting upright. The acceleration on takeoff is gradual, and lasts only a few minutes. Re-entry is a more complicated problem, but there are various technological means to soften the shock of plunging back into the atmosphere.

Q: **You say "technological means." That's the engineer's province, isn't it?**

A: Quite so. We do not try to solve all the problems by medical research. We determine what man's tolerance is to certain stresses—in this case to acceleration or deceleration under various conditions. Remember the heroic experiment on a sled by Col. John P. Stapp! Then it is up to the engineers to provide a vehicle well within the tolerable limits. That is the kind of consultation between the medical researcher and the engineer that I mentioned earlier.

But I also would like to mention that we have physicians and physiologists of great skill who have developed animal capsules and recording devices that amaze the visiting engineers.

Q: **One last question: There is always so much talk about the time table—how about this in space medicine?**

A: The time table in astronautics will be determined by space technology in the first place. We in space medicine must be able to sense all the possible future technological developments for at least 20 years and make our plans accordingly. The solution of some of the biological problems may take 10 years or more. Therefore the space doctors must work on *all* conceivable problems at the same time to meet all the technical advancements in astronautics. And the time is *now!*

. . . There could be other dangerous conditions in space . . .

. . . We must prepare for more than one man in a capsule . . .

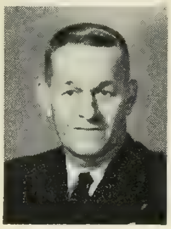
. . . Space timetable will depend on advances . . .

Navy's Reorganization to Affect Research

Rear Adm. Hayward—probably next DCNO—discusses what's needed from industry

by William O. Miller

WASHINGTON—The increasing importance of research and development in the Navy is pointed up by the proposed upgrading of the present assistant chief of Naval operations for research and development to deputy chief of Naval operations. With this would go the three stars of a vice admiral, putting the Navy's man on a par rankwise with his opposite numbers in the Army and Air Force.


HAYWARD

All indications are that the man presently holding the job, Rear Adm. John T. Hayward, will be given another star, and take over the new office with its broadened responsibilities. This would mean jumping him over some 150 senior rear admirals to become vice admiral.

The new deputy chief of naval operations for development, under the proposed plan, would be charged with coordination of all research, development, test and evaluation programs. In addition, he would take over the Guided Missiles Division now under the deputy chief of Naval operations (Air) and would assume scientific data collection and development coordination now carried out by the Office of Naval Research.

The proposal recommends that the organization of the DCNO (Development) be aligned by weapon systems to be responsive to the weapon system concept. Another major change proposed would be merger of the Bureau of Ordnance and the Bureau of Aeronautics in a Bureau of Naval Weapons.

Secretary of the Navy Thomas S. Gates, Jr., has said he will announce his decision regarding the reorganization recommendations about May 1.

• **Hayward's views**—In discussing the growing responsibilities of his office, Adm. Hayward recently made several observations: research and development efforts of the services should not be combined; the nation needs one space agency; his door is wide open for research suggestions from industry; in missiles, solids have the edge on liquid propellants; and he does not think the state of the art has progressed far enough for a nuclear aircraft crash program.

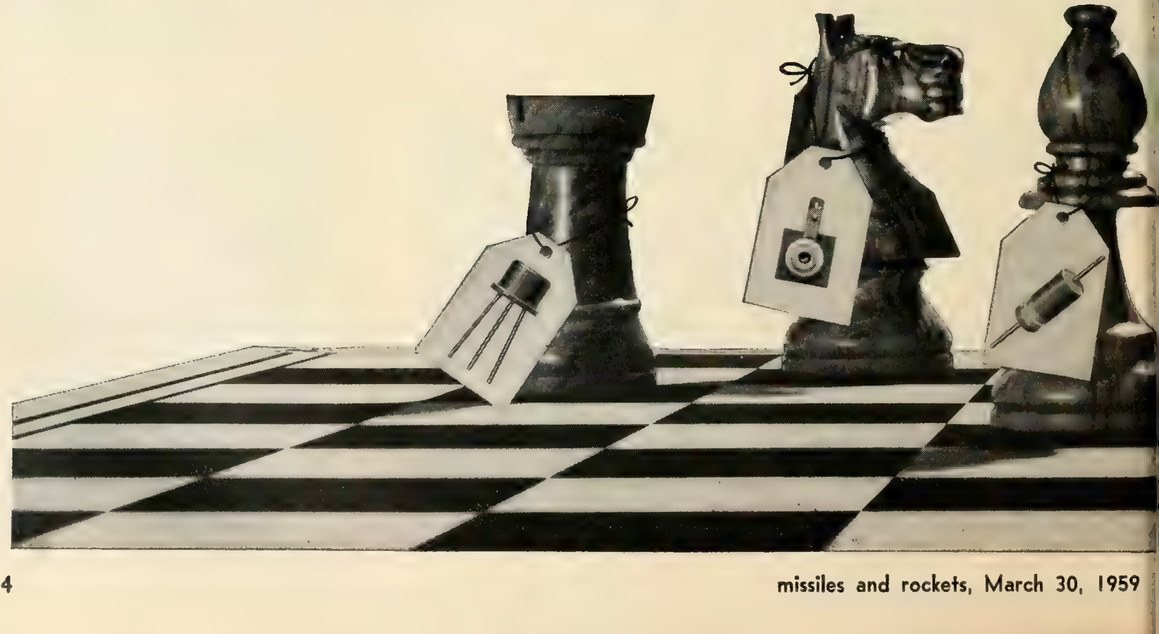
Hayward recently told the House Space and Astronautics Committee that he favors a single space agency and that the amount of money he had asked for Navy R&D work had been cut by one third.

"Most of the $248.7 million cut which resulted in reducing the budget from the requested $770.7 million to $522 million," Hayward said, "will be taken out of the systems part of R&D operations, representing about 40% of the budget and program activity."

Major systems affected by the cut, Hayward said, include the Naval Tactical Data System, the antisubmarine seaplane replacement for the P5M Marlin and the technical development plans of several other systems.

Hayward told the Congressmen that if he had gotten the additional $249 million he had asked for, $150 million would have been put into basic

space gambit!



and applied research.

• **Areas**—What areas of investigation would get emphasis if he were given the money? Solid state physics, various electronic phenomena and low-energy nuclear physics.

He said the various areas of interest under investigation and development are difficult to define. More than 1500 universities and other non-profit organizations hold contracts for research work through his office. The number of contracts with private industry exceeds this.

"It's hard to put a project in a specific area," Hayward said, citing solar battery component work as a state-of-the-art example. "The solar battery works beautifully in the *Vanguard* satellite and might work just as well in communications equipment taken ashore by Marines. The MASER could have many applications all across the front just as the transistor currently is being utilized. Experimental work with pentaboraine and water for torpedo propulsion units could well have application in the missile field," he added.

• **How obtained**—How does his office decide who does what research?

"It's a two-way street," he explains. Frequently the office goes to industry and outlines a requirement, then considers proposed approaches, and then lets contracts. On the other hand, research institutions or industrial firms may come to Hayward's office to sell.

Hayward cited as an example Aerojet-General's work on slow burning gas-generating solid propellants.

"Aerojet came to us and showed results of some work they had done on their own with ammonium nitrate 'cigarette burning' grain solid propellants," Hayward said. We liked what we saw and told them to go ahead. They ended up with some really fine results in the field of torpedo propulsion, which is only part of the whole field of gas generating fuels."

As an example of the other method, Hayward cited how the Navy went to industry with a broad problem of non-acoustic submarine detection research.

"We liked the proposals of three outfits, Stromberg-Carlson, General Electric and Ramo-Wooldridge," he continued, "and we gave contracts to all three." The results are evident.

Communications, Hayward said, is the greatest obstacle to full utilization of the nuclear submarine. A key research problem must be solved, which will enable submarines to communicate reliably with aircraft and surface ships. This, he said, is only one problem in the physics of the sea. He pointed out that the Russians' oceanographic program is 30 times the size of this country's.

• **Centralization?**—Hayward is all for one space agency and for centralization of authority in scientific programming. However, that is just half the story:

"We must have centralization in authority, but decentralization in management and implementation," he said.

However, he does not favor a single military R&D organization.

"Centralization in research is bad, because each of us has different problems and the problems must be related to the environment," he explained. He believes the Advanced Research Projects Agency is serving a very useful purpose as a coordinator of the efforts of the military.

• **State of the art**—Consideration of the state of the art has been neglected in this country, Hayward said. It is impossible, he added, to invent on schedule after coming up with a full-blown system—prior "home work" in the state of the art and availability of reliable components would make it quicker and cheaper to put together a sensible system.

He said better program management could be had with more emphasis on component development and less on weapon systems reaching ahead of the current state of the art.

Program analysis would do much to cure the ills of the present system. The admiral had these recommendations:

1. Decide what is to be done.

2. Explore the state of the art in the particular area so as to be able to measure the risks involved.

3. Limit the number of risks insofar as possible by designing within the state of the art.

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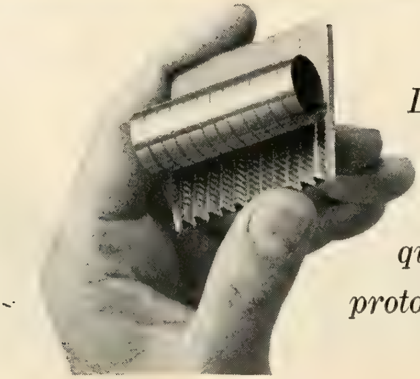

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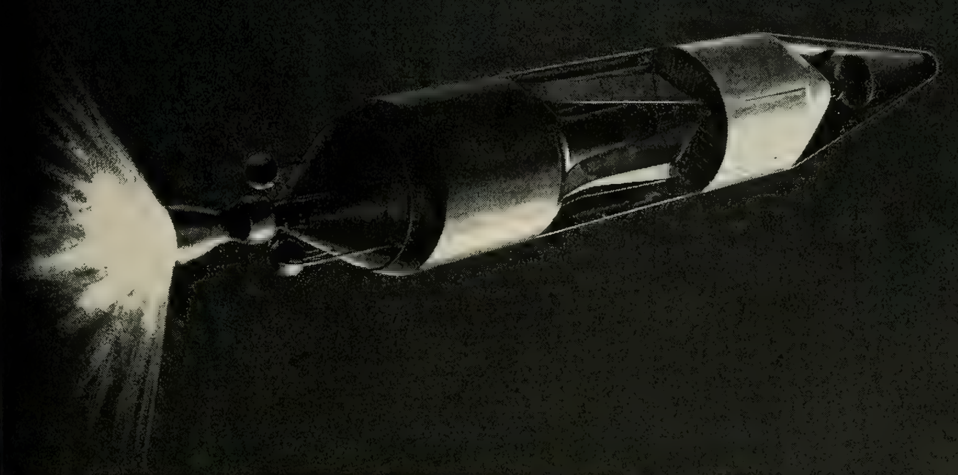

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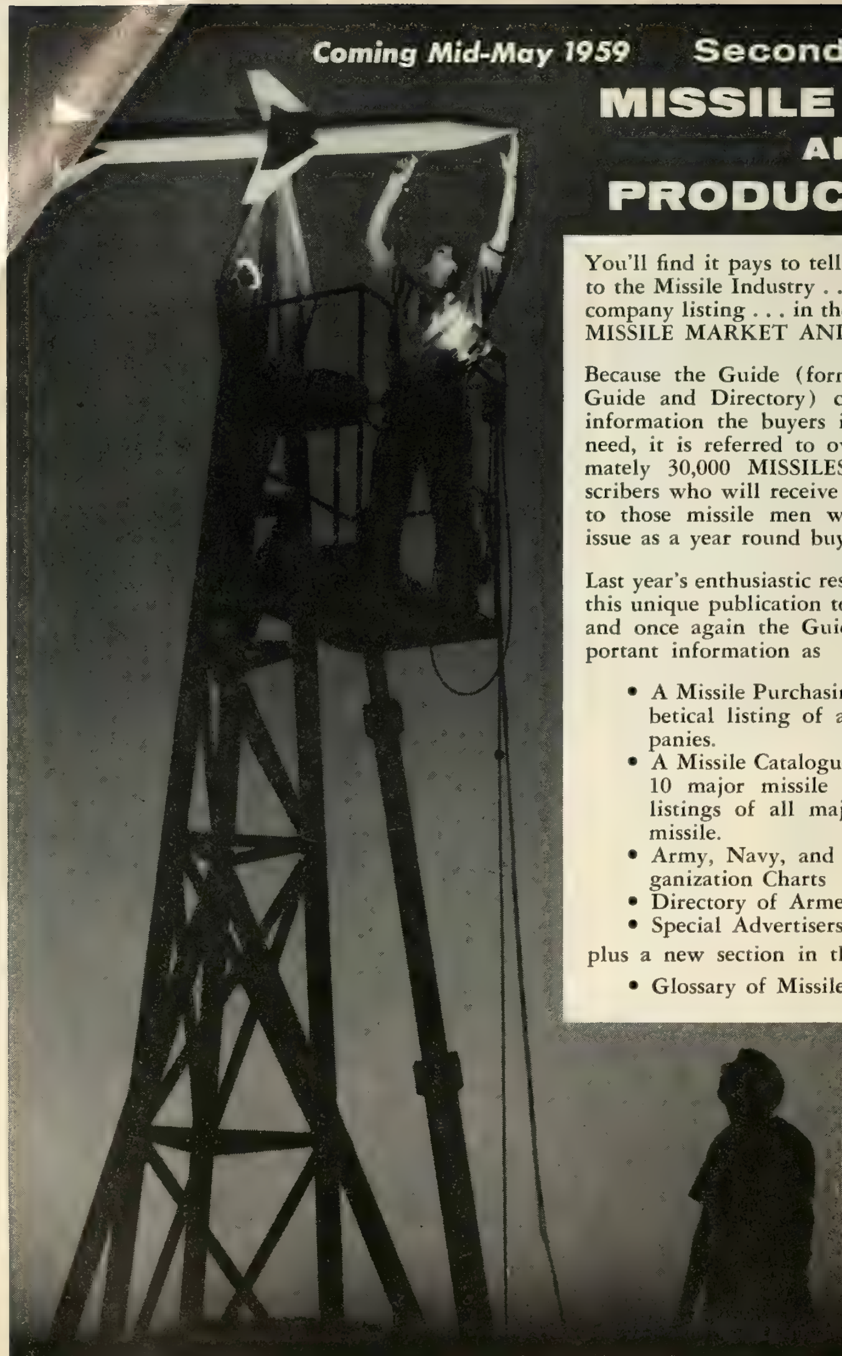

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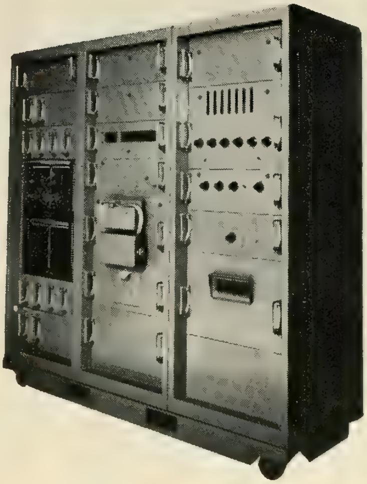
DATICO Described As A Near-Universal Test Facility



Programmed tester developed by Nortronics automatically checks out complex military hardware; company says it will sharply cut costs.

by Charles D. LaFond

ANAHEIM, CALIF.—A practical dream three years ago and a prototype only one year ago, the Digital Automatic Tape Intelligence Check-out is today a proven test facility.

Dubbed DATICO, this programmed automatic check-out system was developed here under the steady guidance of Dr. William F. Ballhaus, general manager and vice president of the Nortronics Division of Northrop Aviation, Inc.

DATICO is the result of a farsighted engineering effort to reduce the myriad of specialized single- and limited-purpose test equipments necessary to check out complicated military hardware. The goal was to produce a single complex having almost universal applicability to missile and aircraft systems.

It has been functioning successfully for more than 2000 hours of operating life during the past year. Check-out tests have been performed on several missile and aircraft systems, subsystems, and components. The results to date show very substantial savings in time, manpower, and dollars.

• **Arguments against**—The concept of automatic systems testing does not stand without opposition. Many have argued that the development of such a facility would only result in an unreliable, over-complicated monstrosity. Opponents have maintained that by its very nature operating personnel would lose the skills necessary to repair it upon failure. Another convincing case has been made based on its wartime use. "There will be no time or even any need for extensive systems testing," they say.

Nortronics believes that DATICO answers these arguments completely and convincingly. To better understand what it can do, we can first see how it is constructed and then consider its designed features.

• **System description**—The DATICO system (see p. 30) is comprised of five major sub-systems: programmer, scanner and service section, measurement section, comparator, and readout. For high-speed testing, all may operate automatically. A manual override switch is provided to allow the operator, at his discretion, to correct improper adjustments, verify or challenge results, or to perform other control functions.

A failure-alarm system is incorporated in DATICO which locates any malfunction immediately; modularized sub-systems permit rapid replacement of defective units without the need for tools. The system also provides fail-safe operation if malfunction occurs in the system under test or within DATICO.

• **Programmer**—A pre-wired patch board and punched information tape establish the test functions and parameters. Together, they are small in size, lightweight, and readily installed in the programmer. The responses of all of the other four sub-systems are determined by the programmer in sequential operations. In addition, the programmer provides a decimal-to-binary data conversion which is used to store binary limit values in the comparator.

• **Scanner and service section**—Address and command. These are the operating modes of the scanner, an electro-mechanical communicator. Under programmer demand, the scanner selects from many the applicable test point. Until the address function is accomplished, the programmer cannot advance.

In the command mode, all of the various service equipments providing stimuli to the machine under test are controlled through a relay section—sequentially actuated on command. A series of relay matrices establishes the applicable test configuration.

• **Measurement section**—Two basic measuring devices make up this section: a digital multimeter and an extremely accurate universal counter-timer. The multimeter transforms ac and dc voltages, voltage ratios, and resistances to digital values. Similarly, frequency or frequency ratio, events-per-unit-time, count, pulse width, time interval, and period are changed to digital values by the counter-timer. The timer employed is accurate to one part in a million.

• **Comparator**—All of the binary-logic circuitry necessary for determining in- or out-of-tolerance conditions of the various measurements is contained in the comparator. It, too, is a completely electro-mechanical unit possessing memory, decision, and command capabilities. As stated earlier, binary limit values are supplied to the comparator by the programmer for storage.

Thus, when a measured value is received, it can be compared within these limits. "Hi-Go-Lo" signals are generated based on this evaluation. A simplified diagram of these command and resulting read-out functions is shown (p. 31).

The evaluation by the comparator is based on digital-computer arithmetic, or, more specifically, it employs complementary subtraction (p. 32). A carry-go, or "computer yes," command to continue testing can only occur when (1) the upper measurement limit exceeds the test reading and (2) the test reading exceeds the lower limit. If either comparison results in no carry, the read-out is printed in red on the record tape. Simultaneously, alarm circuits are actuated and the test sequence is halted. Testing can continue only if the faulty area is corrected or if the operator employs the manual override switch.

- **Read-out**—Obviously, test data read-outs can be provided satisfactorily in many ways. The DATICO prototype system was provided with one of the simplest, but probably more reliable and practicable methods.

A visual display provides the operator with the test-point number, measured test value (decimal), and the comparator evaluation of either "hi," "lo," or "go." In case of malfunction, a letter indicating the area of failure is caused to replace the normal comparator decision. Likewise, when settling periods are programmed, an explanatory symbol replaces the comparator decision.

A printer provides a permanent tape record of test results, in decimal form, along with the test-point identification number. Satisfactory test results are printed in black, unsatisfactory results in red.

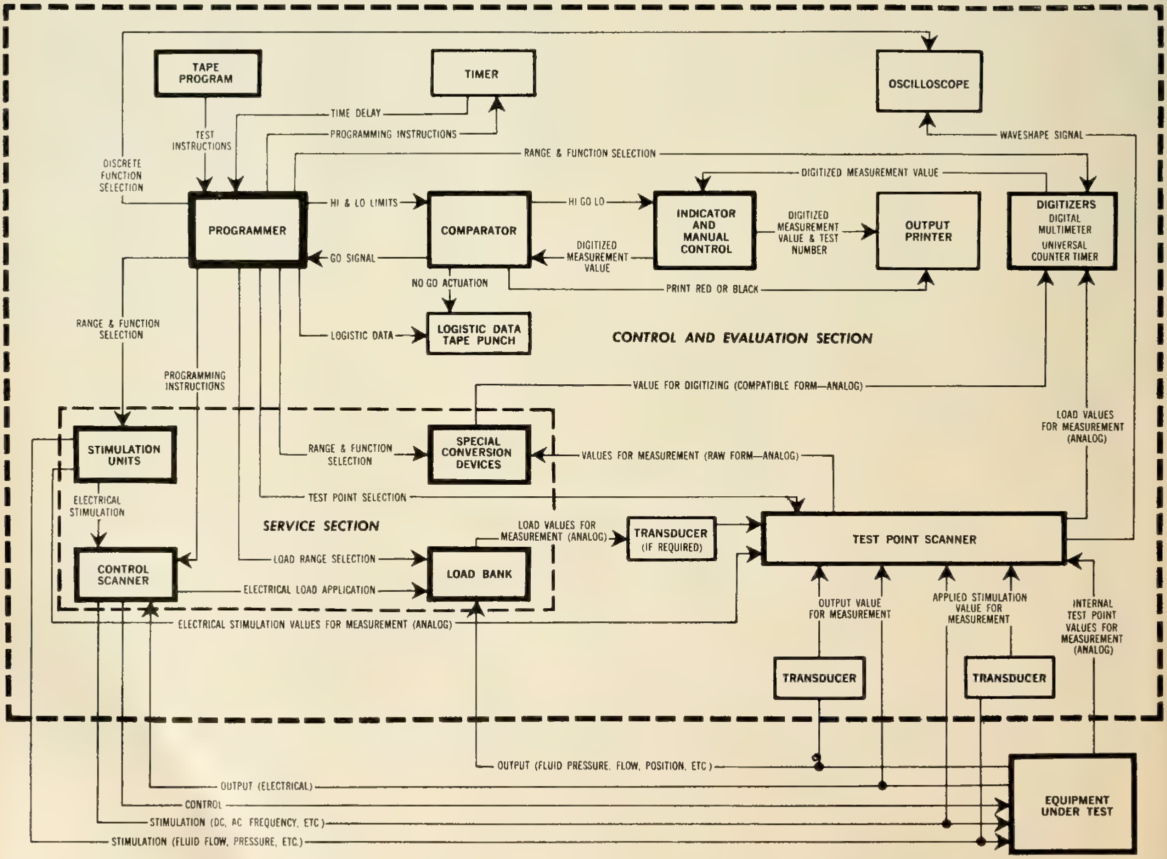
A supplementary read-out can be obtained by adding an auxiliary tape punch unit to record all test failures. This provides a means for direct teleprinter transmission to obtain replacement parts or for computer use in developing statistical failure data.

A horn provides audible alarm for out-of-tolerance results, and, simultaneously, a warning lamp is lighted.

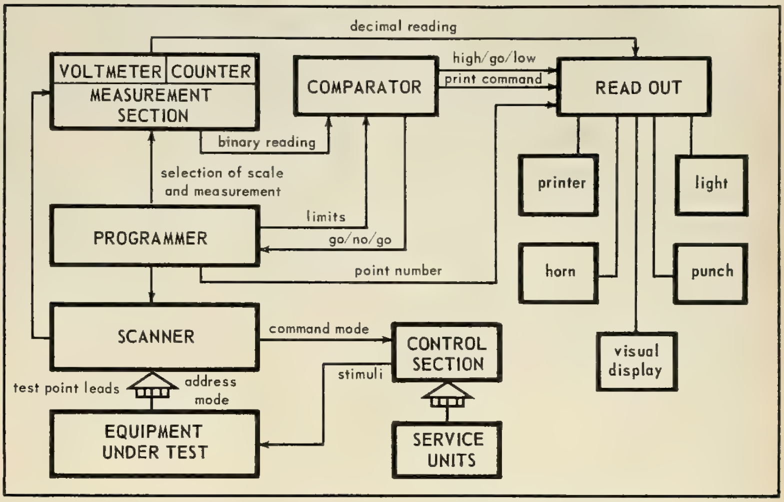
Design Considerations

What can DATICO do and how does it do it? We know what we would like to have a "universal" check-out system do, but how closely does DATICO fill the bill?

- **Adaptability**—The first step, following an analysis of the test needs for a particular system-to-be-tested, is to "marry" DATICO to the subject. The switching theory utilized in DATICO is highly standardized, and its integration with the test subject is rapid. For example, only minimum change is needed to apply it to airborne and ancillary components following an original weapon-system marriage with DATICO. The use of perforated mylar-paper tape and a wiring panel individualize the particular system check-out.


TAPE PROGRAM
TIMER
OSCILLOSCOPE
TIME DELAY
PROGRAMMING INSTRUCTIONS
TEST INSTRUCTIONS
DISCRETE FUNCTION SELECTION
RANGE & FUNCTION SELECTION
WAVESHAPE SIGNAL
DIGITIZED MEASUREMENT VALUE
PROGRAMMER
HI & LO LIMITS
COMPARATOR
HI GO LO
INDICATOR AND MANUAL CONTROL
DIGITIZED MEASUREMENT VALUE & TEST NUMBER
OUTPUT PRINTER
DIGITIZERS
DIGITAL MULTIMETER
UNIVERSAL COUNTER TIMER
GO SIGNAL
DIGITIZED MEASUREMENT VALUE
NO GO ACTUATION
PRINT RED OR BLACK
RANGE & FUNCTION SELECTION
LOGISTIC DATA
LOGISTIC DATA TAPE PUNCH
CONTROL AND EVALUATION SECTION
PROGRAMMING INSTRUCTIONS
VALUE FOR DIGITIZING (COMPATIBLE FORM—ANALOG)
LOAD VALUES FOR MEASUREMENT (ANALOG)
STIMULATION UNITS
RANGE & FUNCTION SELECTION
SPECIAL CONVERSION DEVICES
VALUES FOR MEASUREMENT (RAW FORM—ANALOG)
TEST POINT SELECTION
ELECTRICAL STIMULATION
SERVICE SECTION
LOAD VALUES FOR MEASUREMENT (ANALOG)
TRANSDUCER (IF REQUIRED)
TEST POINT SCANNER
CONTROL SCANNER
LOAD RANGE SELECTION
LOAD BANK
ELECTRICAL LOAD APPLICATION
ELECTRICAL STIMULATION VALUES FOR MEASUREMENT (ANALOG)
OUTPUT VALUE FOR MEASUREMENT
APPLIED STIMULATION VALUE FOR MEASUREMENT
INTERNAL TEST POINT VALUES FOR MEASUREMENT (ANALOG)
TRANSDUCER
TRANSDUCER
OUTPUT (FLUID PRESSURE, FLOW, POSITION, ETC.)
OUTPUT (ELECTRICAL)
CONTROL
STIMULATION (DC, AC FREQUENCY, ETC.)
STIMULATION (FLUID FLOW, PRESSURE, ETC.)
EQUIPMENT UNDER TEST

THIS TYPICAL DATICO functional block diagram has been proposed for use with *Nike-Hercules* system.



COMMAND AND readout functions are shown in system block diagram.

- **Operational scope**—DATICO can now perform, under human observance and ultimate control, all the functions necessary to isolate and indicate faulty or out-of-tolerance chassis, circuits, and modular components. It can provide both temporal test observations for the operator and a permanent printed and/or punched record of an entire test program.

- **Self-checking**—In addition to accomplishing its major testing role, a universal check-out system must perform another duty. To provide test information only is not sufficient. There must be reasonable assurance at all times that the data produced are correct and complete. DATICO had to be self-calibrating and self-checking. Calibration is automatically employed at regular intervals or it may be accomplished prior to critical tests. Through the use of its own special test tapes and wiring panel, DATICO can check-out and verify its calibration. The system is self-stopping in case of malfunction.

All this can be performed by DATICO with a minimum requirement for decision and manual operation by the test operator.

- **Portability**—But, what about portability and power requirements? To perform as required is fundamental; yet, if the bulk and weight of the check-out system are excessive or the power needs too unusual, all of this fine performance and flexibility would be ludicrous.

As designed for testing the Army's *Nike-Hercules* guided missile system, all of the DATICO equipment will be mounted in two standard Army type M-109 vans. A trailer will house the required primary power source, such as a 115 V, 60-cps, single-phase, 3-kva generator.

- **Testing time**—Of necessity, DATICO is a low-speed test system. But operating at a rate of approximately 20 measurements per minute, less time is required normally to complete the actual tests than is required for the connection and warm-up of the tested item. The testing speed is governed by the scope of the measurement, and it must be compatible with the process or reaction time of the item being checked out.

- **Reliability**—Reliability of prototype models of DATICO has been very high. Component failures have been negligible, no stepping switches have failed and only a few relays have been replaced. Silicon diodes experienced the greatest number of failures and these resulted from faulty experimental circuit connections—the diodes were subjected to improper voltages. Four vacuum tube failures comprised the bulk of the remaining failures.

- **Personnel skill levels**—A last, but certainly far from least, consideration inherent in the development of DATICO is the skill-level requirements for operating it. To be most useful to both military and industry users, DATICO had to be operable by persons available in a normal manpower pool.

Certainly an experienced electronics system engineer, trained in the principles of programming and on the operation of DATICO, is necessary. He will be the man to analyze the system under test, determine and prepare the test program and test limits, and alter test sequences to keep abreast of equipment modifications. But this one engineer can be used to supervise many test facilities without compromising his efficiency. Skill level: college degree in electrical engineering, or equivalent; equipment design experience, and a nine-week specialized training course.

A well-trained electronic-equipment specialist, versed in advanced electronic theory, can handle the close supervision of one or more test facilities. Six weeks of DATICO training will be sufficient to qualify him, but he must be familiar with the systems being tested.

One operator-maintenance man is required for each DATICO system. Drawn from the upper-middle skill-level group in an average electronics-technician pool, he can be qualified with four weeks of specialized training.

Finally, an operator-trainee should be provided. Basic electronics training and a three-week specialized course should be sufficient to turn him into a useful assistant to the DATICO operator.

- **Current production**—The success achieved by Nortronics in the development of DATICO is attested to not only by its application to such systems as the *Snark, Nike,* and *Sergeant* but in its current backlog. In progress now is a two-phase program to integrate this check-out system with the Army's *Nike-Hercules* system and to develop DATICO for universal application to all six of the currently operational Army Ordnance missile systems.

The Air Force is currently using DATICO for testing airborne radio equipment. It also has ordered development of a multi-purpose check-out system for electronic equipment.

A Nortronics spokesman has indicated that because of its diverse applicability, the DATICO concept is currently being considered by many of the large missile and aircraft prime contractors, some commercial airlines, NATO, and several European sources.

The reason: Nortronics says that the use of DATICO can result in savings of up to 75% in manpower, 90% in overall checkout time, and 50% in acquisition cost.

- **Limitations**—It would be naive to presume that this early design of DATICO is not without certain limitations. Here are the principal limiting features: (1) There are no solid-state switching components employed. It was decided during the initial development of DATICO to hold to sound, proven engineering practices to facilitate early mass production. Transistor switching was saved for more sophisticated facilities of the future.

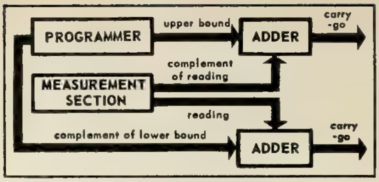
(2) Although faster than already

existing test practices, DATICO is a relatively low-speed device. For many applications, where tests might be performed on the order of 10,000 per second, DATICO is too slow.

(3) Basically, only Go or No-Go indications are provided. Conversely, all of the test limits must be capable of definition to be measurable.

(4) This is an extension of (3). That is, trends cannot be derived from test results. There is no provision in the data for indicating the overall condition of the system with respect to accuracy, reliability and safety.

• **Future developments**—Employing the DATICO philosophy, Nortronics is continuing its program to produce improved designs and greater sophistication in its complementary systems. These are now in the latter stages of development.



COMPARATOR logic diagram.

A smaller, low-cost unit is in progress called DATIMITE. Weighing less than 200 lbs., this portable system is transistorized and employs new comparison and measurement techniques. It is designed for factory, depot and field use.

A nearly completed high-speed universal tester is called NORSCAN—Nortronics System Computing Analyzer. Representing the most current state-of-the-art, the designers believe that this facility provides the answer, for other applications, to all of the limitations in DATICO. Rugged, completely transistorized and completely flexible, this system provides a "confidence index" to indicate how good a Go reading really is.

NORSCAN utilizes a switching matrix capable of making 10,000 measurements per second. An analog-to-digital signal data convertor provides conversion with an accuracy of 0.01% and at a speed of 25 microseconds. An internally programmed digital computer uses a magnetic drum to store up to 500,000 information bits and a core buffer having a capacity of 1000 bits. A 400-character-per-second tape reader feeds the input to the computer. Once done, the test procedure is programmed automatically thereafter.

more about the missile week

(Continued from page 11)

Deployment of 35 more U.S. missile units in Europe by the end of 1959 has been disclosed by the Defense Department. The breakdown: 3 *Nike*, 5 *Honest John* and 2 *Corporal* battalions and one squadron each of IRBM and *Matador* missiles will be delivered by July 1 to Italy, France, Germany, Turkey and Great Britain. By Dec. 29, 16 *Honest John*, 6 *Nike* battalions and one IRBM squadron will be delivered to Denmark, Norway, France, West Germany, the Netherlands, Greece, Turkey and Great Britain. Assignment of units by nation is not known, except the IRBM's will go to Britain under the Mutual Assistance Program pact.

Expect payload cost-per-pound to drop to $100 by 1964, says ABMA's H. H. Koelle. Bigger vehicles, more powerful fuels, higher firing rates and recoverable boosters will do it. Koelle notes the payload pound cost already has plunged from $1 million in 1957 to $50,000 currently and probably will hit $10,000 in 1960.

Forgings of high temperature-resistant NST 881, a new titanium alloy are being evaluated for use in *Dyna-Soar* landing gear. Mallory-Sharon Corp., Niles, Ohio, reports production forgings of "excellent" long-term characteristics at 1100 F and short-term characteristics at 1600 F have been made without difficulty.

Universal-Cyclops Steel Corp.'s Refractomet Division has succeeded in producing a 36x96-inch sheet of columbium .028 inch thick from a 325 lb. ingot. The company also has cast a 470 lb. columbium 1% zirconium alloy ingot. Both achievements are considered breakthroughs in milling the metal.

Industrial quantities of 98-99% pure neodymium—which appears capable of increasing heat resistance of magnesium alloys used in missiles—are being produced by the Nuclear Corp. of America, Burbank, Calif. One of the more abundant rare earths, neodymium has a melting point of over 1800°F and a boiling point exceeding 5400°F.

A 10-inch ram-jet generating 3500 F is being used at Chance Vought Aircraft Inc. to test nose cones for re-entry capability.

Refusal of the Air Force to hand a ballistic missile program management survey to the Government Accounting Office is causing Capitol Hill repercussions. Members of the House Government Information Subcommittee brand the action strictly "illegal." They may demand a judicial review of the "executive privilege" exercised by the AF to withhold the report.

Battle over NASA's expanded Wallops Island test range is getting hotter. The Federal Aviation Agency is now in the fray on the use of air space and the routing of aircraft which fly close to the range. FAA indicates NASA ought to use existing ranges at Cape Canaveral and Vandenberg AFB.

Red tape snarling cost-plus-fixed-fee research and development contracts "just isn't worth it" to Charles E. Hastings, president and chief engineer of Hastings-Raydist Inc., a small electronics instrument firm. Hastings told the Senate Small Business Subcommittee his company broke off dealings with the government in 1955 to avoid "financial ruin." Costs running too high to absorb involved obtaining approval in each contract for purchasing, accounting, wage administration, personnel, security and every variety of record keeping. The Small Business Administration is investigating.

Texas Instruments at IRE announced both a major developmental advance in ultra microscopic semiconductor solid circuitry and the introduction and availability of a new semi-conductor device. The circuitry involves the creation of a complete match head size working circuit within tiny single pieces of semi-conductor material. The product is a gallium arsenide diode which operate at temperatures far beyond the capabilities of any other commercial semi-conductor device (325°C).

Fast tax write-off on 70% of $8.2 million allocated to development of the *Centaur* lox and hydrogen rocket engine has been granted the Pratt & Whitney Division of United Aircraft Corp. by the Office of Civil and Defense Mobilization. Other write-offs were okayed for: Boeing Airplane Co., 65% of $2.5 million for R&D on space vehicles and missiles; General Electric Co., Syracuse, N.Y., 55% of $978,000 for ballistic missile electronic guidance system; Aerojet-General Corp., 60% of $175,000 for R&D of rocket propulsion systems.

an m/r exclusive

Nuclear Explosions in Space

A scientific explanation of PROJECT ARGUS and how an electron accelerator could lead to creation of an artificial particle belt

First of four articles by PROF. S. FRED SINGER

In the April 6 issue: Nuclear Explosions in Space and their Direct Effect upon Space Vehicles Carrying Men or Nuclear Warheads.

In the April 13 issue: Nuclear Explosions in Space and Their Direct Effect upon Radar and Long-Range Communications including ICBM Detection.

In the April 20 issue: Nuclear Explosions in Space and How They Can Be Detected by a Great Variety of Scientific Techniques.

WASHINGTON—On March 19, 1959, the press revealed the existence of Project *Argus.* During August and September of 1958, three separate atomic blasts were set off 300 miles above the South Atlantic. The atomic bombs reportedly were of small size, in the kiloton range.

They were carried to altitude by three-stage *X-17* rockets launched from the guided missile ship USS Norton Sound. The effects of the explosions were observed not only by the *Explorer IV* satellite, but also from ground stations more than 8000 miles away in the North Atlantic where artificial aurora was reportedly produced by the atomic explosions.

The results were said to have confirmed the predictions of Nicholas C. Christofilos, who instigated the project.

• **Questions raised**—The release of this data, though incomplete, immediately raises questions of a political, military and scientific nature. Some of them are: (1) Can atomic explosions in space be detected, and if so, what are the possible methods? (2) If concealment of such tests is possible, can their effects be harmful to inhabitants of the earth? Can they, for example, produce changes in weather, as has been claimed by Soviet scientists? (3) From the military point of view, is it conceivable that such explosions can blanket the radar defense system against ballistic missiles? (4) Can the effects of these explosions interfere with worldwide communications? Assuming such military applications are possible, does this imply a serious revision of strategic concepts involved in anti-ICBM work?

Further problems are raised by the more direct effects on vehicles and men operating in space. Do such explosions have effects on human beings in satellites or in vehicles of the *Dyna-Soar* type, or even on high-flying aircraft, or can such effects be overcome by adequate shielding? Are direct effects on missiles possible? Could, for example, missile electronics be destroyed or the missile warhead be triggered?

From a scientific point of view, the major questions raised are whether such explosions can tell us more about the origin of the natural radiation belts around the earth; whether such explosions can affect and possibly do away with the radiation belts or whether they increase the level of radiation. These questions lead naturally to the possibility that there may be other methods, aside from atomic explosions, for affecting the natural radiation belts or for producing an artificial one.

• **Answers available**—As we shall see, practically all of these questions can be answered in a direct way, some of them affirmatively. The only equipment needed is a thorough understanding of the output of an atomic bomb, the properties of the earth's magnetic field and atmosphere at high altitudes, and the interactions of the products of the atomic explosion with the field and the atmosphere.

All of the relevant facts and theories have already appeared in the open scientific literature. The writer, for example, developed a theory for the trapping of charged particles in the earth's magnetic field as long as three years ago. It, in turn, was based on basic theories developed by the Swedish astrophysicist Alfvén. Even earlier, Ross Gunn in the U.S. and a Norwegian astrophysicist, Störmer, made many fundamental mathematical investigations of the motion of particles in a magnetic field.

The only item in doubt and not released is a description of the nature of particles and radiations coming from an atomic explosion. However, a basic knowledge of nuclear physics, and in particular of the fission process of uranium, can supply much of the needed information. Thus, any competent physicist either here or in the Soviet Union or in Europe can work out the consequences of atomic explosions in space.

• Trapping in earth's field—Basic to all the discussion to follow is an understanding of the motion of charged particles in a magnetic field. The important facts are shown in Fig. 1. It should be noted that only charged particles of small mass are affected by the field of the earth; this means protons, ions and electrons. A rocket which is charged up will not describe such spirals in the earth's magnetic field; neither will an uncharged particle such as a neutron. They are essentially not deflected by a magnetic field.

About the Author

* Professor S. Fred Singer of the University of Maryland, became interested in the possibility of trapped particles forming a "radiation belt" around the earth while performing research on aurora phenomena. In 1956, he authored a paper on the theory of trapped particles in the earth's magnetic field, and a year later, worked out some of the consequences of hydrogen bomb explosions in space.

At that time he published what effects such an explosion would have on the moon. He withheld from publication the effects of such an explosion on the earth's magnetic field; but wrote his ideas to several outstanding scientists.

During this same period (1956-1957) Dr. Singer was acting as consultant to the Air Force on Project *Farside*, a project to fire rockets into space from a balloon-lifted platform, and designed to check on—among other things—the existence of a belt of trapped radiation. The *Farside* firings took place in the fall of 1957 but were not sufficiently successful to provide conclusive data. *Explorer I*, of course, proved the existence of the radiation belt.

Dr. Singer has been associate professor of physics at the University of Maryland since 1953. He was graduated from Ohio State University and holds master's and Ph.D degrees in physics from Princeton. He served in the Navy in 1945-1946, and from 1950 to 1955 held an Air Force commission. From 1946 to 1950 he was with the Johns Hopkins Applied Physics Laboratory. Because M/R believes that information on the effects of atomic bursts in space is of vital importance to everyone engaged in space engineering, we have asked him to prepare this series of technical articles on the subject.

TABLE 1

Properties of Earth's Radiation Belts

	HARD (COSMIC-RAY)[a]	SOFT (AURORAL)[b]
ORIGIN	From the decay of cosmic-ray albedo neutrons which come out of the earth's atmosphere	From solar corpuscular streams with subsequent acceleration near the earth
NATURE	Protons between 10-400 Mev	Electrons and protons of less than 1 Mev
SHIELDING	Difficult to absorb and shield	Easily absorbed
LOCATION	Equator and low latitudes	Auroral latitudes
	Close to the earth	Far from the earth
TIME DEPENDENCE	Constant in time	Variable, increases when sun is active

References: Physical Review Letters, Vol. I, p, 181, 1958; and Transactions American Geophysical Union, Vol. 38, pp. 175-190, 1957

TABLE 2

Travel Times in Earth's Magnetic Field for Particles*

(assumed to be 5 million electron volt electrons)

TRANSFER TIME (between "mirror" points in opposite hemispheres):
Along low latitude line of force—1/10 second
Along auroral line of force—1/2 second

DRIFT TIME AROUND EARTH (for particles moving along line of force which reaches maximum distance R_e in the equatorial plane and intersects the top of the atmosphere, about 300 miles, at magnetic latitude λ ; R_e is measured in earth radii—4000 miles)

R_e	λ	Drift time (seconds)
1.1	17°	730
1.5	35°	540
3.0	54°	270
5.0	63°	160
7.0	68°	120

*Reference: Transactions of American Geophysical Union, Vol 38, pp. 175-190, 1957

A proton or electron will simply spiral about a line of force. The spiral can be quite flat with pitch angle of 90° just as in a cyclotron. Or it can have a smaller pitch angle, in which case it will progress along the line of force and trace out a helix or screw thread. The pitch angle depends essentially on how the particle is started out in its motion in the magnetic field.

The situation becomes of great interest when the magnetic field changes in intensity, as it does in the case of the earth. As the particle moves into a region where the magnetic field increases (as shown by the fact that the lines of force crowd together), the pitch angle steepens, the spiral becomes flat, and the particle is reflected at the point where the pitch angle reaches 90°.

A quick look at Fig. 2 will show that the earth's magnetic field is constructed in such a way that its strength increases as one approaches the earth's surface. Therefore, a particle released in space will spiral about a line of force until it reaches a point where the magnetic field is strong enough to reflect it. From then on it will bounce back and forth between the mirror points and be trapped.

The two major problems now are: (1) How do particles get into the magnetic trap, how many, and where? (2) How long are particles stored in the magnetic trap and what happens to them to remove them?

• Natural radiation belts—It had been pointed out earlier, that the sun may inject particles in the earth's magnetic field, which then remain trapped. This hypothesis was developed to account for the aurora and magnetic storms. It was also suggested that high-altitude probes should look for this trapped radiation (see the article on Project *Farside* in m/r, October, 1957). The *Pioneer* rocket demonstrated the existence of a belt of such trapped particles, very likely connected with the aurora, and thereby turned the hypothesis into fact.

The inner radiation belt, found by Dr. James A. Van Allen in *Explorer* satellites, is probably not connected with the aurora and therefore not of solar origin. We believe that it is produced by the impact of cosmic rays on the earth's upper atmosphere which results in emission of high-energy neutrons. On the way out into space some of these neutrons decay radioactively into protons and electrons which are then trapped by the earth's magnetic field.

The cosmic-ray theory predicts a maximum close to the earth and also predicts that this radiation belt can only exist at latitudes near the equator (see Fig. 3 and Table 1).

- **Particle motion**—In addition to bouncing back and forth between the mirror points, which are located on about the same meridian, it has been shown that the particles will also drift in longitude. Positive particles will drift to the west, and negative particles, such as electrons, will drift to the east.

It is of great practical importance in discussing the effects of high-altitude explosions to know the speed with which the particles transfer from the Southern to Northern Hemisphere and the speed with which they drift around the earth. The calculations made in connection with the trapped particle theory of magnetic storms and aurorae are reproduced in Table 2.

An important consideration in discussing high-altitude atomic tests is to know what fraction of the particles released is immediately dumped into the atmosphere and what fraction is stored in the earth's field. Calculations show that this result depends on the exact location at which the explosion is carried out.

This can be seen as follows: If we release a particle above the equator with a certain initial velocity and therefore a certain initial pitch angle, then as it proceeds along the line of force it will either be reflected before it hits the atmosphere, or it will hit the atmosphere first, in which case it will be absorbed and therefore removed from storage.

We can now define a critical pitch angle at the equator: particles that have a smaller angle hit the atmosphere while those that have a larger angle are reflected and stored. Table 3 gives this information for a number of lines of force. [A line of force is defined by the latitude at which it intersects the earth's surface. It then sweeps out to a very high altitude above the equator and re-enters the earth in the other hemisphere at approximately the same magnetic latitude.]

If we assume an isotropic burst above the equator, then the last column in Table 3 gives the fraction of particles stored. However, if we move along the same line of force off the equator, the fraction stored becomes less and less.

Finally, if the explosion takes place just above the atmosphere, practically all of the particles will be released into the atmosphere and only a few will be stored. This fact can be clearly seen from Fig. 2. Only particles which start out with a pitch angle of nearly 90° will again be reflected above the atmosphere at the other hemisphere, but as we shall see later, their lifetime will not be very long.

The point of bomb burst therefore is controlled by the effect one wants to achieve. If one wants to dump the particles into the atmosphere in the opposite hemisphere, for example in order to produce interference with communication, the burst altitude should be as low as possible. For added effect, the burst should take place over a magnetic anomaly where the magnetic field is higher than usual. Then the particles going to the opposite hemisphere will enter the atmosphere much deeper and produce more pronounced effects.

On the other hand, if one wants to lose as little of the radiation as possible into the atmosphere and store

TABLE 3

Fraction of Particles which Remain Trapped*

It is assumed that particles are released isotropically at a point which is near the plane of the magnetic equator. Particles having a pitch angle less than α_c are immediately absorbed into the atmosphere. The rest remain trapped with a life time which increases with the particle's pitch angle α_e (always referred to when the particle crosses the equatorial plane). Particles with $\alpha_e = 90°$ stay in the equatorial plane and live longest.

LINE OF FORCE DEFINED BY		CRITICAL PITCH ANGLE	FRACTION TRAPPED**
R_e	λ	d_c	
1.1	17°	55°	57%
1.5	35°	27°	89%
3.0	54°	12°	97%
5.0	63°	9°	99%
7.0	68°	2°	99.9%

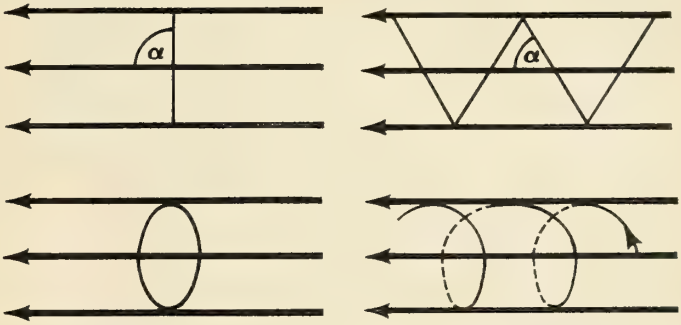
*Reference: Physical Review Letters, Vol. 1, p. 171, 1958

**This fraction is greatly reduced when the burst point is off the equatorial plane, and becomes very small when it is at the limit of the atmosphere.

Figure 1

PARTICLE MOTION AND REFLECTION IN MAGNETIC FIELD

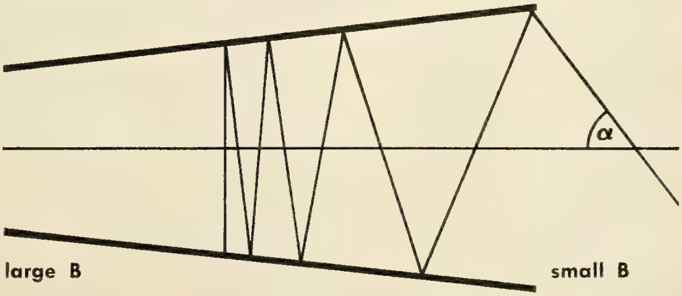
CASE 1: HOMOGENEOUS FIELD



(a) Pitch angles α=90°
(particle does not advance)

(b) Pitch angle less than 90°
(particle traces out helix)

CASE 2: NONHOMOGENEOUS FIELD (shown by converging lines of force)



As particle moves into region of stronger field B the pitch angle steepens, reaches its maximum value of 90°, at which point the particle is reflected. The relation between α and B is given by $\sin^2 \alpha / B = \text{constant}$ (Reference: H. Alfven Cosmical Electrodynamics, Oxford Press, 1950).

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it for a long time, the burst point should be high above the equator.

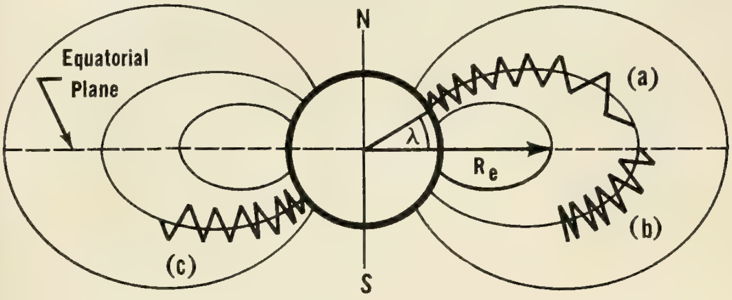
- **Particle lifetime**—A crucial problem is the lifetime of the particles trapped in the field. In the absence of any atmosphere and in a perfect magnetic field, the particles could stay trapped forever and build up to very high intensity values. But in fact there exists a very tenuous atmosphere around the earth which becomes more and more ionized the higher we go. As the trapped particles collide with atmospheric atoms or ions or atmospheric electrons, they are scattered and their pitch angle changes slightly.

If, by chance, the pitch angle should drop below the critical value, then the trapped particle is immediately released into the atmosphere and of course disappears. It is almost immediately obvious that those particles which penetrate deepest into the atmosphere, where the density is highest, will have the shortest lifetime, while the particles which stay close to the equator, and therefore at high altitudes, will be preserved much longer.

But in addition to the atmosphere, particles can also be scattered when they collide with inhomogeneities of the magnetic field, and this effect sets a limit to lifetime at higher altitudes. But at low altitudes the atmospheric effect is so much stronger that it determines the lifetime of the trapped particles.

Figure 2

PARTICLE TRAPPING IN EARTH'S MAGNETIC FIELD



R_e (distance in equatorial plane) defines line of force; also defined by λ, the latitude at which it intersects the earth (or top of atmosphere).

CASE (a): Particle starts with pitch angle less than α_c, hits atmosphere before it is reflected.

CASE (b): Particle starts with large α_e, is reflected and stored.

CASE (c): Particle starts with same pitch angle as in (b), but too far off the equatorial plane; it hits atmosphere.

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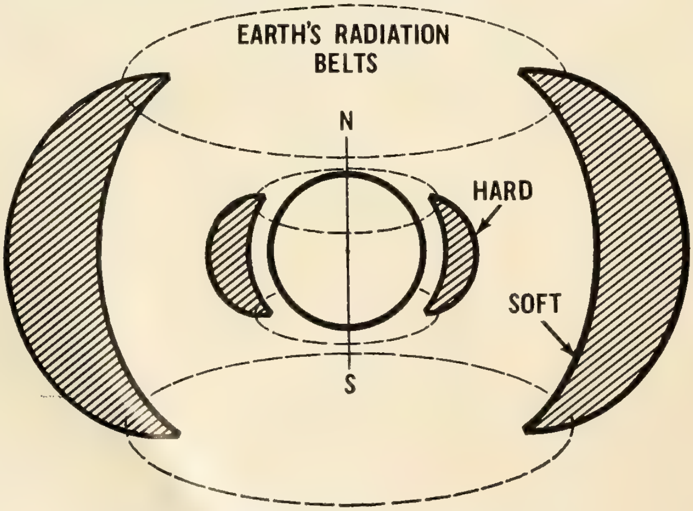
Figure 3

EARTH'S RADIATION BELTS



From Pioneer data (after Van Allen).

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- **Artificial radiation belt**—For scientific purposes, an atomic explosion is a very crude injection device. A much more refined measurement is possible if one uses an electron accelerator. Then the energy of the electrons can be precisely controlled, the direction of injection can be controlled if desired, and the number of electrons released is definitely known. It can be turned on or turned off at will.

Because of these advantages, it is very likely that such a project will get underway very soon. With a nuclear test ban in effect, this would be the only way of simulating the particle radiation released in an atomic explosion. Such experiments therefore have a certain military value as well.

From a practical point of view, an accelerator weighing only a few hundred pounds is capable of emitting electrons up to the highest energies present in atomic blasts, something like several million electron volts. The accelerator could be carried aloft in a rocket and enough electrons spewed out to give a significant increase in reading above the normal background of trapped radiation.

On the other hand, it may be more desirable to put the accelerator into a satellite to allow it to operate for a much longer time. The writer has calculated the behavior of an electron cloud released artificially from an accelerator. It will produce a thin curtain of trapped radiation which rapidly spreads over the whole earth. After a few seconds, the curtain will begin to contract and assume the shape of a napkin ring. After a few days, most of the radiation will have disappeared and the ring will become smaller and smaller. Finally, the particles will be concentrated mainly around the equator.

An average lifetime for the phenomenon is of the order of two weeks. This should be long enough to allow detailed observations both with sounding rockets which go through the layer and with satellites which can traverse the layer every time they orbit into it.

The creation of an artificial radiation belt raises implications concerning its military value. The project can always be carried out so that no harmful effects will be produced either on the earth or on space vehicles, but a more detailed discussion is reserved for later.

Army Progresses in Micro-Modules

60 companies assist in development of sugar lump-size radios. Future holds promise of single module for circuit functions

NEW YORK—The U.S. Army's micro-module program has made remarkable progress in its subminiaturization of whole assemblies. Underway since April, 1958, the program already has resulted in the development of radios the size of a sugar lump. Working models showing this concept were unveiled here for the first public showing by the Army and Radio Corporation of America.

RCA is prime contractor in the $5 million, two-year contract. In cooperation with RCA are over 60 other companies providing materials and components. In time, it is expected that most of the electronics industry will become involved with the task as equipment builders or as element and module suppliers.

The Army announced that progress so far indicates the promise of a tenfold reduction in size and weight of today's most refined equipment. That is, those equipments already using printed circuits, transistors and other miniaturized components. In some cases the reductions can be 20 to 1, and further shrinking is considered feasible, according to Dr. Charles B. Jolliffe, vice president and technical director of RCA.

• **Tiny flakes**—The smallest units of a micro-module are tiny flakes of conducting, semi-conducting, or insulating materials, 0.01 inch thick and 1/3 inch square. Controlled processing turns them into micro-elements which can do the job of specific components such as resistors, transistors, capacitors, diodes, inductors and crystals. A group of microelements are stacked up, interconnected, and encased to form the micro-module itself. These operate at complete circuits, such as amplifiers, oscillators, and other complex electronic functions.

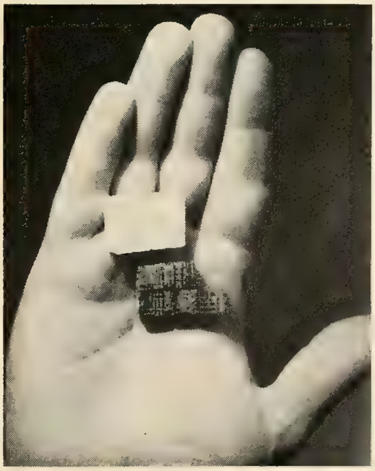
The whole concept, envisioned to take advantage of continuing progress in electronics, will permit combining numerous circuit functions within a single module. In addition, the modules will be compatible with conventional component structures.

Micro-modules are expected ultimately to play an important part in space age missilery. Their small size can save critical space and weight in satellite systems and rockets—perhaps manned.

The size of sensory, data-gathering and telemetering systems such as those currently being placed in orbit could be considerably reduced through the use of micro-modules. They could make possible larger and more diversified space operations with no gain over present electronic poundage.

Smallness, highly important within itself for military and other purposes, is but one merit of micro-modules.

• **Promise**—Since the program was launched, tests carried out by RCA and Army Signal Corps engineers show that the tiny cubes promise to be highly dependable, long-lived, use little power, deliver high performance, and greatly simplify repairs. They are extremely rugged due to their simplicity and monolithic shape.



Sperry's SCAR Permits Star-fixing by Periscope

WASHINGTON—Some of the details of an electronic navigational aid used by our nuclear-powered submarines have been released by the Navy. Designated SCAR, for Submarine Celestial Altitude Recorder, the device permits celestial navigation by a submerged submarine.

"Shooting the stars" is a time-honored and always-reliable method of establishing a ship's location at sea. Nowadays, it provides a means of checking the accuracy of inertial and other advanced navigational systems.

Produced by Sperry Piedmont Company, division of Sperry Rand Corporation, SCAR has been demonstrated successfully in the record-breaking underwater performances of Nautilus, Seawolf and Skate.

With the device installed in a periscope, the navigator has only to sight the sun, moon, or a star and then depress a switch. SCAR then automatically computes the exact altitude of the sighted body. The paper-tape printed results indicate the sighting angle in degrees and minutes, in addition to the exact time of sighting to the nearest second. The timer is accurate within one second per day.

After two or more of these sightings, the navigating officer can establish his position. This last manual computation is a traditional procedure. Thus, SCAR replaces the watch and sextant but with the additional advantage of not requiring the underwater craft to surface.

high-energy fuel
briefs from Callery

More HiCal® in the offing for authorized users—A planned boost in HiCal production over the next few months will provide more than enough fuel for immediate military test program requirements. As a result, Callery will have HiCal-3 available for *authorized* users. If you wish to test HiCal-3 in engines or components in your fuel program, write for specific information. New HiCal-3 Handling Bulletin is available on request.

Diborane now available in developmental quantities at reduced prices—Formerly available in research quantities at $400/lb., Callery's new price schedule for Diborane ranges from $35 per lot for 100 grams ($160/lb.) to $80/lb. in 4/lb. lots.

Ten years of R & D on fuels and propellants—Callery's Research and Development Laboratories in Callery, Pennsylvania, are currently rounding out ten years of extensive work on fuels and propellants. Active in this field since 1948, our R & D Laboratories have been carrying out programs totaling $6 million per year for the last five years.

We can now handle a limited number of new projects for other organizations. Areas of primary interest: fuels and propellants, component testing, inorganic and organometallic chemistry.

New 15-minute Triethylborane-Tributylborane fire-fighting film available for loan. Just write 9600 Perry Highway, Pittsburgh 37.

Lower cost lithium borohydride available—Callery now offers Lithium Borohydride at prices ranging from $1.00/gr. to $180/lb. in 10/lb. lots. $LiBH_4$ is a solid. It melts at about 532°F with decomposition. Decomposition at 1800°F would absorb more than 6000 BTU/lb. It is soluble in hydrazine with a reduction in freezing point, which improves its properties as a rocket fuel.

Offices now in Washington, D.C., and Dayton, Ohio—To contact Callery in the Washington, D.C. area, phone Richard A. Carpenter, Manager, ADams 4-4200. This new Callery office is in Room 709, DuPont Circle Building, 1346 Connecticut Avenue, N.W.

Our new office in Dayton, Ohio, offers specialized assistance to interested parties in that area. Call Anthony C. Hummel at AXminster 3-2752. Office address is 2600 Far Hills Avenue.

Stuart G. McGriff
Product Manager
Fuels and Propellants
Callery Chemical Company

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CALLERY CHEMICAL COMPANY
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. . . FULTON

(Continued from page 18)

program can do is to wring their hands about the threat of 1961-1962. They say: "What will happen then if we project the present type of production missile vehicles to 1962?"

There is no doubt of U.S. superiority in the guidance and control fields, and in tracking and telemetry. We and our allies have a world-wide network of ground stations aiding us in these fields. The USSR has none outside of her territory and satellites.

Let us knock out claims of supposed superiority of the USSR in large thrust boosters at the present time. Samuel K. Hoffman, vice president and general manager of the Rocketdyne Div. of North American Aviation Corp., testified before the House Committee on Science and Astronautics on March 16, 1959, that we have under construction a million-and-a-half-pound thrust engine, and by clustering six to ten million pounds of thrust is entirely feasible.

Do not underestimate our advances in the production and use of IRBM's for the defense of the U.S. and the free world from European bases, as well as from over 250 Free World bases scattered everywhere. We can get to a target with more missiles, more accurate CEP, in half the time, and half the expense of the ICBM long-range missiles.

Russia must depend on an ICBM range of 4000 to 8000 miles launched from her own territory. The U.S. has been smart in moving her defenses to forward bases outside her borders with ranges for IRBM missiles of only 400 to 1500 miles to target areas on the average.

Why should the U.S. take Senator Symington's advice and adopt Russia's strategy of ICBM's? Now—we should fill out our U.S. defense production immediately to support our forward bases which give us defense in depth, and we must now continue emphasis on research and development in the ICBM field rather than production. We should not now make the decision to match Russia's 1961-62 strength as predicted by Senator Symington to be 3000 ICBM's—they are probably the "Big Bertha" cannons of World War I transferred to World War III.

The ICBM capability of all nations has been tremendously handicapped already by the high-space nuclear shots by the U.S. in September, 1958, in the South Atlantic which can knock out most of our present electronic missiles guidance systems. The new U.S. ability to jam and make ineffective radar and radio installations over wide areas has given the U.S. Strategic Air Force.

Air Force a new lease on life because SAC now cannot be stopped, in all probability, by current Russian radar defense methods of standard design. What a breakthrough!

In conclusion, I think the facts show that neither of the major power baseball teams is going to win the game—at least by waging total nuclear war with all of its devastating implications. The game is going to go on, and our best strategy is to keep a present, vigilant deterrent that will keep the other side from waging total war—but also to spend money, not on producing obsolete weapons now, but on research and development that is going to produce the weapons that will win the ball-games of the future.

It is an untidy world, and threats to our national security are a problem that will be with us for some time. Crash programs are not the answer. But a well-considered program which will keep the peace at present, and will also produce the weapons that will keep the peace in future years is the best way to survive in the missile nuclear age.

. . . SYMINGTON

(Continued from page 19)

this country. Economically, the United States is much stronger today than the USSR. With millions less people, we produce more than twice as much as the Soviet does. It is true that their rate of progress, as well as that of the Chinese, is greater than ours, but it is also true that we can far outproduce the Soviets in weaponry with less drain and less strain.

Knowledge of our production potential, however, is not enough. We must use it. There is no time left for complacency. Rather, we should look with clear vision at realties.

Already, the Soviets are ahead of us in important aspects of space exploration. They are also ahead of us in ballistic missiles.

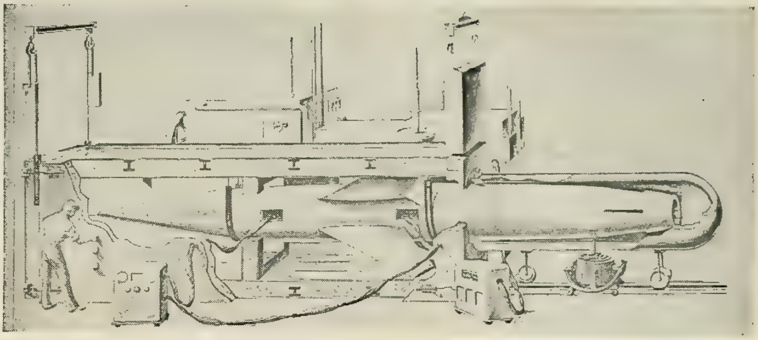
The Sino-Soviet empire already is employing these leads in their dealings with other nations. If we are not to default in our position of leadership in the free world, therefore, we must step up our economic, moral and defense pace.

This does not necessarily mean large increases in our defense spending. We can, and should, cut down the current waste of tax money by discontinuing the production of obsolete and useless weapons systems and also by eliminating existing duplication between the services.

This is no time to lose confidence in our democratic free enterprise system. Now, more than ever before, is the time to reassert that confidence.

ENVIRONMENTAL TEST CHAMBERS

FROM THE CONRAD Inc. FILE

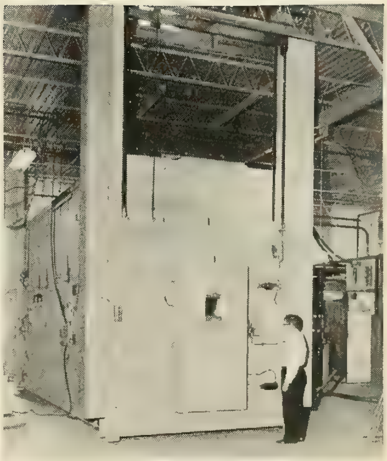


THE IDEA FROM THE CUSTOMER

From The Martin Company in Orlando came the design specifications for an environmental chamber required for missile testing. Drawing upon years of experience in this specialized field, and working closely with The Martin Company, Conrad developed the walk-in chamber illustrated below.

THE RESULT FROM CONRAD, INC.

Delivered to The Martin Company recently, this 1200 cu. ft. Conrad chamber is sectionalized to produce high and low temperatures simultaneously. It consists of three units—main chamber, machinery, and instrument panel. The main chamber can be divided into two chambers with a pressure barrier separating the sections. Temperature range, –120° F. to +650° F., altitudes in excess of 125,000 ft., capable of dissipating 40,000 watts at –100° F.



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"THE MILITARY REQUIREMENTS FOR MOON BASE"

This is the title of one of four major proposals developed within the past 12 months by Martin for the military and astroscientific branches of our Government. The importance of this proposal is two-fold: the inevitability of an actual moon base program by this country within the next 5 years, and; we could and can undertake such a project now—not in theory but in "hard" engineering design. In preparation for that inevitability, Martin already has built the capability for it. One important step was the creation of the Space Flight Division*, which is now directing Phase 1 of Project DYNA-SOAR.

**The Space Flight Division is one of the 7 divisions of Martin*

MARTIN

BALTIMORE·DENVER·ORLANDO

contract awards

NASA

WASHINGTON—The civilian space agency announced it had signed a $5,000,000 contract with General Electric Co. for development of a liquid propellant engine to power the second stage of the *Vega* space vehicle. Delivery is expected early next year.

It said the engine will be a modification of the *Vanguard* first-stage engine. Combined with an *Atlas* vehicle as the first-stage, according to NASA, the *Vega* will be capable of carrying "significant" payloads on interplanetary missions.

Earlier, NASA announced some previously-undisclosed contracts awarded last month, including:

$770,000—**Minneapolis-Honeywell Regulator Co.**, for guidance system for Project *Scout*.

$470,000—**The Smithsonian Institution,** for electronic tracking and data reduction equipment.

$170,000—**Aerojet-General Corp.**, for shipping rigs for Aerojet *Senior* boosters to be used in Project *Scout*.

AIR FORCE

$300,000,000—**Boeing Airplane Co.**, for production of *Bomarc B* solid-fuelled 400-mile ground-to-air missiles and ground support equipment (includes $128,000,000 committed in prior years).

$12,125,000—**American Machine & Foundry Co.**, for design and development of training base launchers for *Titan* (a follow-on contract).

$2,327,000—**Aeronutronic Systems, Inc.**, subsidiary of Ford Motor Co., for classified development and testing of vehicles in support of ICBM program.

$1,000,000—**Catalytic Construction Co. of Pennsylvania**, for setting up the third tactical *Bomarc* base at Otis AFB, Cape Cod, Mass. (a sub-contract from Boeing).

$835,146—**Raytheon Mfg. Co.**, for electron tubes (several contracts).

$518,000—**Sylvania Electric Products Inc.**, for electron tubes.

$483,600—**Telecomputing Corp.**, for precision gyros for *Bomarc* and spare parts for floated rate gyros (add-on contracts from Boeing).

$426,572—**Grand Central Rocket Co.**, for rocket engines and motors in support of *Minuteman* test track project.

$205,573—**RCA Defense Electronic Products Div.**, for various electronic items.

$188,445—**Bendix Aviation Corp., Pacific Div.**, for various electronic items.

$187,652—**Instrument Corp. of Florida,** Melbourne, Fla., for shutter control and synchronization system for Wild BC-4 ballistic cameras.

$140,675—**Varian Associates,** Palo Alto, Calif., for klystron tubes.

$129,000—**Cornell University**, for research on theoretical and experimental investigations in high-speed aerodynamics.

$110,000—**Dynamic Research, Inc.,** Los Angeles, for increase in funds.

$100,760—**New York University**, for continued research on non-linear theories of deformation and buckling.

$93,720—**Sundstrand Machine Tool Co., Sundstrand Aviation Div.**, for recirculating valves and boost pump assemblies in support of *Black Knight* engine.

$79,460—**University of Chicago,** for design, development and production of a prototype model of a cosmic ray counter for experimental, developmental and research purposes.

ARMY

$1,455,197—**Aerojet-General Corp.,** for instrumentation and installation.

$303,458—**Motorola Inc., Military Electronics Div.**, for AN/DKT-8 (XO-4) missile telemetry systems for the *Jupiter* program.

$300,000—**North American Aviation, Inc.,** for rocket engines.

$225,994—**Camco Construction Co., Inc.,** Fullerton, Calif., for storage base P.O.L. at Vandenburg AFB.

$152,954—**Raytheon Mfg. Co.,** for gyro accelerometers for *Hawk*.

$106,160—Gilfillan Bros., Inc., for radio beacons and repair parts (two contracts).

$87,000—Alexis B. Kononoff, Miami, Fla., for design of *Minuteman* launch facilities at Patrick AFB.

$72,500—Rader & Associates, Miami, Fla., for design of *Minuteman* launch facilities at Patrick AFB.

NAVY

$64,600,000—Raytheon Mfg. Co., for further production of *Sparrow III* missiles.

$461,595—Raytheon Mfg. Co., for electron tubes (three contracts).

$238,862—Dale Benz, Inc., Contractors, San Diego, for addition to range operations bldg., Naval Missile Facility, Point Arguello.

$157,500—Westinghouse Electric Corp., for electron tubes.

$72,580—Kuthe Laboratories, Inc., Newark, N.J., for electron tubes.

NASA Planning Bid For Equatorial Launch Site

WASHINGTON—Only big addition to the current launching site program will be a demand for an equatorial launching site. However, the general feeling is that at present National Aeronautic and Space Administration and the Defense Department have all they can say grace over. Result is that the demand won't be heard loudly before the FY 1961 budget is prepared.

Decision as to when and how to ask for the new launching site will be made by NASA in consultation with the Space Council. Preliminary studies made prior to the creation of NASA as well as work to be done by NASA space science groups will establish the need. Timing will depend on the satisfaction of current needs first.

Importance of the equatorial launching site was summed up as follows: "The unique properties of an equatorial orbit lead to a distinct need for an equatorial launching site. These are: (1) narrow track over the earth's surface; (2) best departure point for an interplanatary operation; (3) capability for all other types of orbit; and, (4) a minimum requirement for ground stations and communications systems."

Further studies to be made will undoubtedly consider the possibilities of using ship or islands as launch sites as well as the logistics problems involved in creating an equatorial site.

UCLA Develops New Ceramic-Metal Process

LOS ANGELES—The University of California's Department of Engineering has developed a new process for combining ceramics and metals for application in high-temperature structural members.

The concept involves flame-spraying of thin alternate layers of molten metals and ceramics on a rotating disc. After cooling for a period, this "layer cake" is crushed into small grains.

propulsion engineering

Exotic metals and refractories can be molded to shape with a plasma arc torch that reaches 30,000 degrees F. The arc is struck between two electrodes within the torch; a high-speed gas stream protects the torch from the immense heat and carries, in the molten state, the material to be formed. Metal, fed from wire, is sprayed onto any surface to be coated (the surface does not get appreciably hot). Make a refractory nozzle or nose cone this way: Feed the high-temperature refractory as a powder into the gas stream which carries it into the arc where it melts; spray it on a shaped mandrel; dissolve away the mandrel. Or make a graphite nozzle and spray it with tungsten.

The plasma arc torch was developed by Linde Co. as an outgrowth of earlier plating research. It costs too much for most people who would need it. Electrical back-up alone runs probably $250,000. Because of its high operation noise, Linde will contract individual plating jobs in its own shops. Carbides, zirconium, titanium and Moly-B have been applied to all manner of surfaces, including reinforced plastics.

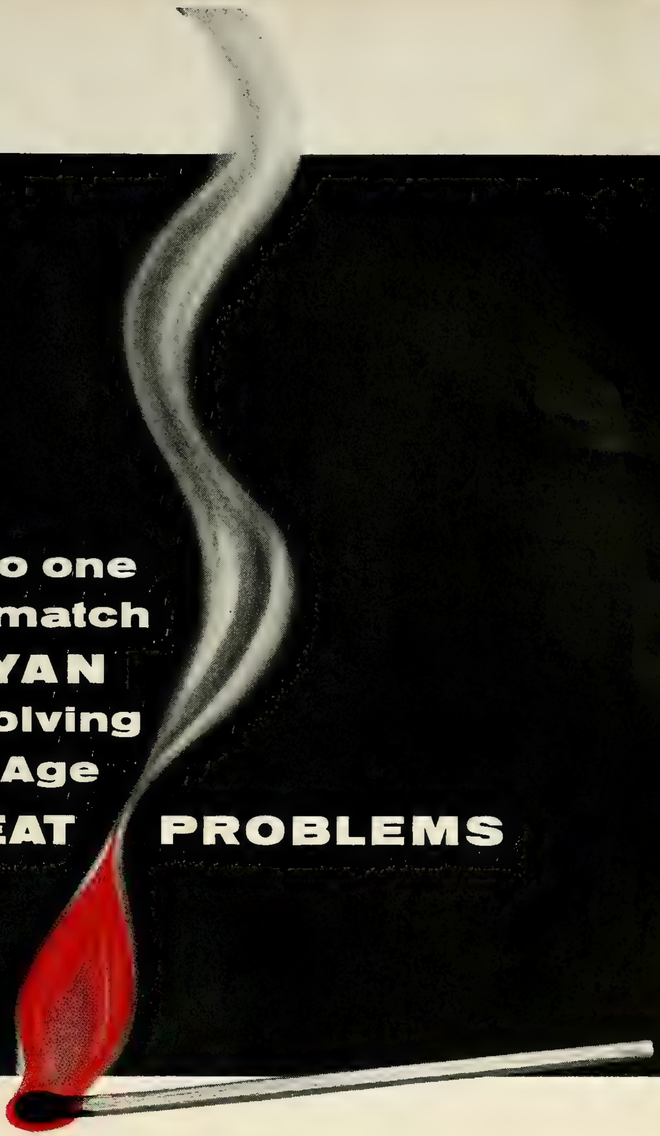
Shippable and storable liquid hydrogen news also comes from Linde. People have been waiting for the National Bureau of Standards' ortho-to-para hydrogen conversion process announced last year to go commercial. "We've been shipping para-hydrogen for quite some time now," says a Linde official, referring to the company's Tonowanda, N.Y., facility. Ortho-hydrogen naturally wants to convert to para-hydrogen, with release of heat which vaporizes the liquid. This is why liquid H_2 is almost impossible to store or ship conveniently. Bureau of Standards speeded up the natural conversion with a ferric oxide catalyst. With nearly all H_2 in a tank in the form of para-hydrogen, there is no further natural warming.

Explosion forming of metal parts is gradually emerging into a science. The latest step: Discovery that an ammonium nitrate-fuel oil combination is synergized—or helped—by water. Most explosion forming is carried out under water. The NH_4OH-oil combination is a superior dry operation explosive. It goes even better under water. Apparently the water cools the gaseous products and shifts the equilibrium in the right direction.

Navy's prepackaged liquid propellants use mixed amines as the fuel, insiders say. Oxidizer is HNO_3. More important than the "package" aspect is the fact that these engines, especially *Guardian*, are successful new developments in variable thrust. Flow rate of fuel and oxidizer is controllable, produces in effect several engines in one.

Hercules Powder's capability in solid rocket engines—as opposed to propellants alone—improves with acquisition of Young Development Laboratories, Rocky Hill, N.J. Young produces filament-wound reinforced plastics, gradually replacing stainless steel and other metals for encasing small grains. A point not widely circulated will get this marriage off to a flying start: Young has been active in Hercules solid propellant development for the past decade.

British liberal press is pushing the government to switch defense reliance from liquid to solid-fueled missiles. The liberals attack Duncan Sandys' recent Defence White Paper as trying to sell the nation on the *Blue Streak* which, they say, is only a "liquid fuel missile of the same technological age group as the *Thor*."



But if you want to try, do this:

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- Shake down 35 high-temperature alloys in the laboratory.
- Fabricate these super-alloys into critical hot-part components for prototype power plants.
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SPACE COMMUNICATIONS

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Lockheed's activities in the missile field began before World War II when the company designed and flew a pilotless aircraft for the Army Air Corps. Today the Missiles and Space Division embraces every facet of research and development, engineering, test and manufacture. It has complete capability in more than 40 areas of science and technology, from concept to operation.

The Division's advanced research and development programs now under intensive study provide a fascinating challenge to creative engineering. These programs include: man in space; space communications; electronics; ionic, nuclear and solar propulsion; magnetohydrodynamics; oceanography; computer research and development; operations research and analysis; human engineering; electromagnetic wave propagation and radiation; materials and processes and others.

Programs such as the Navy Polaris FBM; Discoverer Satellite; Army Kingfisher; Air Force Q-5 and X-7 reach far into the future and require a bold and imaginative approach where only theory now exists. It is a rewarding future which scientists and engineers of outstanding talent and inquiring mind are invited to share.
Write: Research and Development Staff, Dept. C2-29,
962 W. El Camino Real, Sunnyvale, California.

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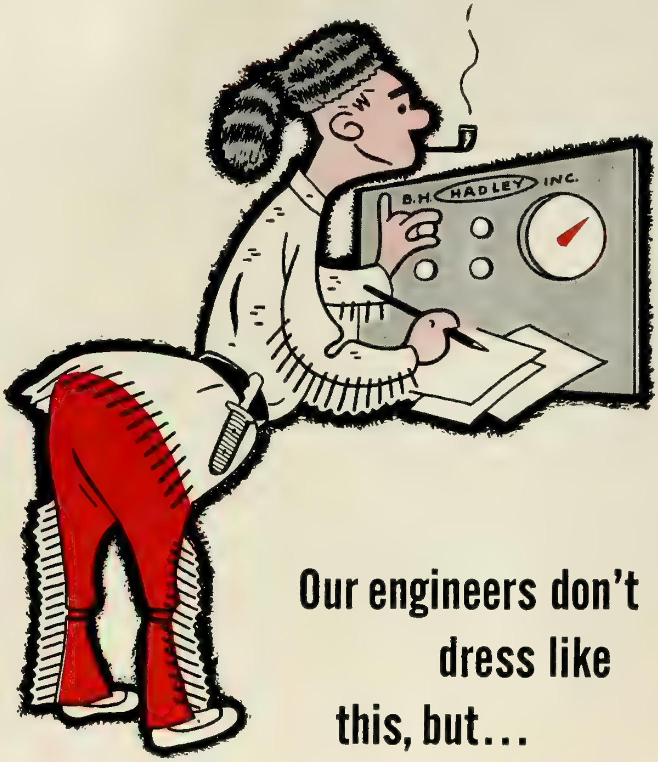
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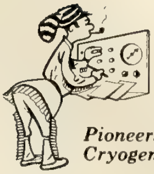

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letters

Thanks from Raborn

To the Editor:

May I compliment you on your choice of your cover illustration (AX-1 *Polaris* launching) contained in your Feb. 2 issue? She is a beautiful lady and we are confident that she will fly like one, and meet all of her requirements.

Rear Adm. W. F. Raborn,
U.S. Navy
Director, Special Projects
Department of the Navy
Washington, D.C.

Bouquet for Haggerty

To the Editor:

It was a great delight and a tremendous pleasure to read the top-notch story prepared by James J. Haggerty, Jr., in the March 9 issue, on the finest and brainiest General (Lt. Gen. S. E. Anderson) for whom I have ever had a chance to work.

Haggerty's story was well researched, factual and seemd to me to give proper credit to a real gentleman and one of the finest Commanders of ARDC.

B. G. Holtzman
Brigadier General, USAF
Commander
Hqtrs. Air Force Office of Scientific Research
U.S. Air Force
Washington, D.C.

Energy Conversion

To the Editor:

I was particularly intrigued by the recent article concerning the chemical energy conversion cell under development by Lockheed. If this development turns out completely successful it could have an effect as far-reaching as—and more immediate than—the development of nuclear energy for propulsive purposes.

This is particularly interesting when consideration is given to the point that such an end usage of fossil fuels would not further pollute the atmosphere with ozone and carbon dioxide—a factor causing grave concern to various scientific agencies. I hope that you will follow this development as it progresses.

Joseph E. Hamilton
37 South Prospect St.
Hagerstown, Md.

Your interest in the round-up is appreciated, and we plan to keep our readers abreast of this development.

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people

KELLY

Dr. Mervin J. Kelly, retiring chairman and former president of Bell Telephone Laboratories, has been engaged by International Business Machines Corp. as a consultant on research and engineering matters. Kelly recently received the James Forrestal Medal of the National Security Industrial Association and the John Fritz Medal for "achievements in electronics, leadership of a great industrial research laboratory, and contributions to the defense of the country through science and technology."

Three top-level executive promotions at North American Aviation's Los Angeles Division have been announced: **Charles E. Ryker** was named controller; **James E. Driskell** assumes the post of director of personnel, and **Robert S. Johnson** becomes assistant to the general manager.

EHRICKE

Krafft A. Ehricke was recently elected a member of the board of directors of Kentrol Hawaii, Ltd., electronics firm. A pioneer in missile development and space flight, Ehricke helped to develop the German *V-2* and later worked with the U.S. Army's rocket and missile development program. He was a member of the team which developed the Convair *Atlas*, America's first ICBM. He retains his post at Convair-Astronautics.

Dr. Alan Lovelace was named one of the ten winners of the Eleventh Annual Arthur S. Flemming Awards "for his foresight in recognizing the need for a research program in the area of inorganic polymers," which led to establishment of a section by the Air Force to conduct such research. The competition honors outstanding men under 40 years of age in the scientific or management fields. Lovelace is a senior project engineer at ARDC's Wright Air Development Center, Dayton, Ohio.

The Martin Co. has announced appointment of **George D. Sands,** physical chemist, as director of scientific requirements. He was formerly Chief of the Nuclear Branch of the Army's Transportation Research and Engineering Command, Director of Scientific Requirements.

Ira H. Abbott is the new Deputy Director of Aeronautical and Space Research for NASA. He will also serve as Assistant Director of Research (Aerodynamics and Flight Mechanics), a position he has held since NASA was established in October last year. Starting with the National Advisory Committee for Aeronautics, NASA's predecessor, in 1929 as a junior aeronautical engineer at the Langley Aeronautical Laboratory, Abbott was named Assistant Director of Research in 1949.

CLAVIER

Andre G. Clavier, who retired as vice president and technical director of ITT Laboratories, has been appointed scientific advisor to the Laboratories president, **Henri Busignies.** Formerly in charge of company-sponsored projects at the ITT's research division, he has held the post of vice president since 1956 and is celebrating his 30th anniversary with the ITT System.

Dr. Robert M. Page, father of the pulse radar system, has won the third annual Captain Robert Dexter Conrad Award, for outstanding R&D achievements for the Navy. Page, Director of research for the Naval Research Laboratory, built the first pulse radar system which detected aircraft in flight in 1934. He holds more than 40 patents with 27 pending and his recent inventions include the monopulse radar.

The award was established by the Office of Naval Research.

Lt. Col. Martin L. Raines has been assigned as the Army Ordnance Missile Command's liaison officer to the National Aeronautics and Space Administration at Langley Field, Va. He will be concerned with space programs which the Missile Command works on under NASA direction.

Nicholas E. Golovin, former chief scientist at the White Sands, N.M., Missile Range has been named director of New Technical Operations Division in ARPA. He will manage the agency's military space technology programs and advanced research in ballistic missile defense and solid fuels.

GROSCH

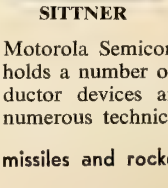
Dr. Herbert R. J. Grosch is the new space program manager for International Business Machine Corp.'s military products division. He will be in charge of the *Vanguard* Center in Washington, D.C., and will maintain liaison with the space laboratory in the division's Owego, N.Y., plant and the Watson scientific computing laboratory at Columbia University.

Dr. George C. Szego has joined Space Technology Laboratories, Inc. He will conduct research on advanced energy sources and propulsion systems in STL's special projects office. He formerly was manager of space propulsion operations at General Electric Co. in Cincinnati.

Dr. Vincent J. Cushing, recently of Armour Research Foundation, has been appointed a weapon system manager of the missiles and space systems division of United Aircraft Corp. and will supervise all phases of its efforts in small tactical weapons. Since 1950 Dr. Cushing has been director of propulsion and fluids research of the Armour Research Foundation at the Illinois Institute of Technology in Chicago.

Propellex Chemical Division, Chromally Corp., reports the addition of project engineer **Wendell L. Haubein,** in connection with a solid propellant gas generator contract.

Recently appointed to the post of director, systems management division, Cook Electric Co., is **Harold Neal,** formerly with Stromberg-Carlson, a division of General Dynamics Corp.



SITTNER

Dr. Willard R. Sittner takes over as manager of the Semiconductor Division of the Sperry Rand Corp. Since 1949 he has served as manager in major semiconductor operations at Bell Telephone Laboratories, Western Electric Co., Hughes Aircraft Co., Pacific Semiconductors Inc. and Motorola Semiconductor Products. He holds a number of patents on semiconductor devices and is the author of numerous technical papers.

missile business

by William E. Howard

While defense spending remains on even keel, shifting allocations and greater concentration on selected missile models have added a note of caution to some individual forecasts for 1959. Generally, the industry outlook is for sales and profits to continue at the 1958 pace or higher in a competitive climate. Some uncertainty may be attributable to lower backlogs as the new year started. An m/r survey of 11 missile/aircraft manufacturers shows 1958 backlogs at $8.4 billion—$1.1 billion less than the previous year.

Of the 11 companies, only three reported higher dollar volumes of unfilled orders as they went into the new year. They were the Martin Co., $832 million—up $37 million; Republic Aviation Co., $442 million—up $90 million; and Ryan Aeronautical Co., $129 million—up $12 million. The biggest backlog was reported by Boeing Aircraft Inc., which had $2.4 billion in orders on tap as of Jan. 1. The figure is $7 million below its record backlog of a year ago.

Down $259 million at $1.5 billion was Douglas Aircraft Co. There were some dramatic changes in the sales and earnings picture for companies with heavy investments in the missile-space business, and having small commercial stakes. Decreased earnings in 1958 were reported, on the other hand, by firms with strength in both military and commercial business. These setbacks were attributed to the writing off of stepped up development costs.

In this latter category were Boeing and Douglas. Both had 1958 sales increases of more than $100 million, bolstered by missile/space orders. However, Boeing's earnings dropped $10 million and those of Douglas slid $13 million. Reflecting the gathering momentum of the Space Age are Aerojet-General Inc. and the Martin Co. Aerojet-General sales soared from $161 million to $218 million and earnings rose from $3.8 million to $6 million in 1958. Martin increased sales by $60 million—at $483 million—and its earnings of $11.7 million were up almost $2 million from the previous year.

Aerojet-General President Dan A. Kimball forecasts that in the 1959 FY ending Nov. 30 sales should hit about $300 million—an increase of about 37%. In a speech to some investment bankers in Chicago, Kimball said sales and earnings for quarter ending Feb. 28 were up approximately 67% from the corresponding period of a year ago. He indicated that the company—which makes engines for most of the major U.S. missile programs—is in the midst of a heavy recruitment drive.

"We expect to have more than 20,000 (employes) by mid-1959," the former Navy secretary said. The current payroll is 18,000. A reflection of the concern of some over changing industry conditions is contained in the annual report of Jack & Heintz, Inc., missile electronics firm. President Frank R. Kohnstamm says "the outlook for this year is hard to forecast." Funds for both research and production of missiles, he notes, "are being concentrated in selected models and, at the same time, the expenditures for manned military aircraft—and the number of models in production—are gradually diminishing."

Taking note of a 1958 drop of $6 million in J&H sales, Kohnstamm said he is hopeful of increasing volume this year on the strength of greater sales effort and with new products getting into the hardware stage. One thing appears certain. Kohnstamm told his stockholders, the industry this year is "acutely competitive."

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when and where

MARCH

Society of Automotive Engineers, National Aeronautic Meeting, Hotel Commodore, New York, March 31-Apr. 3.

APRIL

Conference on Electrically Exploded Wires, sponsored by the Thermal Radiation Laboratory of the Geophysics Research Directorate of the Air Force Cambridge Research Center, Somerset Hotel, Boston, Apr. 2-3.

American Society for Quality Control, Portland Chapter, Oregon Museum of Science and Industry, Portland, Apr. 3-4.

1959 Nuclear Congress, Municipal Auditorium, Cleveland. For information: Engineers Joint Council, 29 West 39th St., New York, Apr. 5-10.

Fifth National Military-Industrial Conference, Palmer House, Chicago, Apr. 6-8.

American Welding Society, 1959 Welding Show and 40th Annual Convention, International Amphitheatre and Hotel Sherman, Chicago, Apr. 7-10.

International Conference on Fracture, Sponsors: Air Force Office of Scientific Research/Solid State Sciences Div., Office of Naval Research, National Science Foundation, National Academy of Sciences/NRC. Massachusetts Institute of Technology, Cambridge, Apr. 12-16.

Air Force Association, World Congress of Flight, Las Vegas, Apr. 12-19.

Aeronautical Training Society, 17th Annual Meeting, Desert Inn, Las Vegas, Apr. 16-17.

Institute of Radio Engineers, 11th Annual Southwestern Conference and Electronics Show, Dallas Memorial Auditorium, Dallas, Apr. 16-18.

American Society of Tool Engineers, Annual Meeting, Schroeder Hotel, Milwaukee, Apr. 18-22.

American Rocket Society, Man-in-Space Conference, Hotel Chamberlain, Hampton, Va., Apr. 20-22.

Institute of Radio Engineers, Spring Technical Conference on Electronic Data Processing, Cincinnati Section, Engineering Society Bldg., Cincinnati, Apr. 21-22.

Institute of Environmental Engineers, 1959 Annual Meeting, La Salle Hotel, Chicago, Apr. 22-24.

American Society of Mechanical Engineers, First National Metals Engineering Conference, Hotel Sheraton-Ten Eyck, Albany, N.Y., Apr. 29-May 1.

American Rocket Society, Controllable Satellite Conference, Massachusetts Institute of Technology, Cambridge, Apr. 30-May 1.

MAY

Air Force Office Scientific Research/Chemistry Div. and Electromechanical Society, Symposium on Electrode Processes, Philadelphia, May 3-7.

Institute of Radio Engineers, 11th National Aeronautical Electronics Conference, Dayton, Ohio, May 4-6.

Instrument Society of America, 5th National Instrumentation Flight Test Symposium, Seattle, May 4-7.

International Scientific Radio Union, Spring Meeting, Willard Hotel, Washington, D.C., May 5-7.

1959 Electronics Components Conference, Benjamin Franklin Hotel, Philadelphia, May 6-8.

Institute of Radio Engineers, Seventh Regional Conference and Trade Show, University of New Mexico, Albuquerque, May 6-8.

Armed Forces Day, Observances scheduled throughout week of May 9-17.

Aviation Writers Association, 21st Annual Meeting and News Conference, Washington and Willard Hotels, Washington, D.C., May 10-16.

The Society for Experimental Stress Analysis, 1959 National Spring Meeting, Sheraton Park Hotel, Washington, D.C., May 20-22.

Institution of Electrical Engineers, The Radio and Telecommunication Section, Earl's Court, London, May 21-27.

American Rocket Society, Institute of the Aeronautical Sciences, American Institute of Electrical Engineers and the Instrument Society of America, Brown Palace and Cosmopolitan Hotel, Denver, May 25-27.

American Society of Mechanical Engineers, Design Engineering Conference, Convention Hall, Philadelphia, May 25-28.

Federation Aeronautique Internationale, Annual Conference, Moscow, May 28-31.

JUNE

American Rocket Society, Semiannual Meeting, San Diego, June 8-11.

United Nations Educational, Scientific and Cultural Organization, Paris, June 15-20.

Cornell University Industrial Engineering Seminars, Cornell University, Ithaca, N.Y., June 16-19.

American Institute of Electrical Engineers, Air Transportation Conference, Olympic Hotel, Seattle, June 24-26.

RCA Demonstrates Thimble-Size Tubes

WASHINGTON—In a recent demonstration before representatives of the electronics industry, military, and press, RCA introduced prototypes of its thimble-size electron tubes.

Called "Nuvistors," the tiny tubes are capable of operation in temperatures from −320°F to +350°F. Since they are larger and require high power, the Newistors are not expected or intended to replace transistors.

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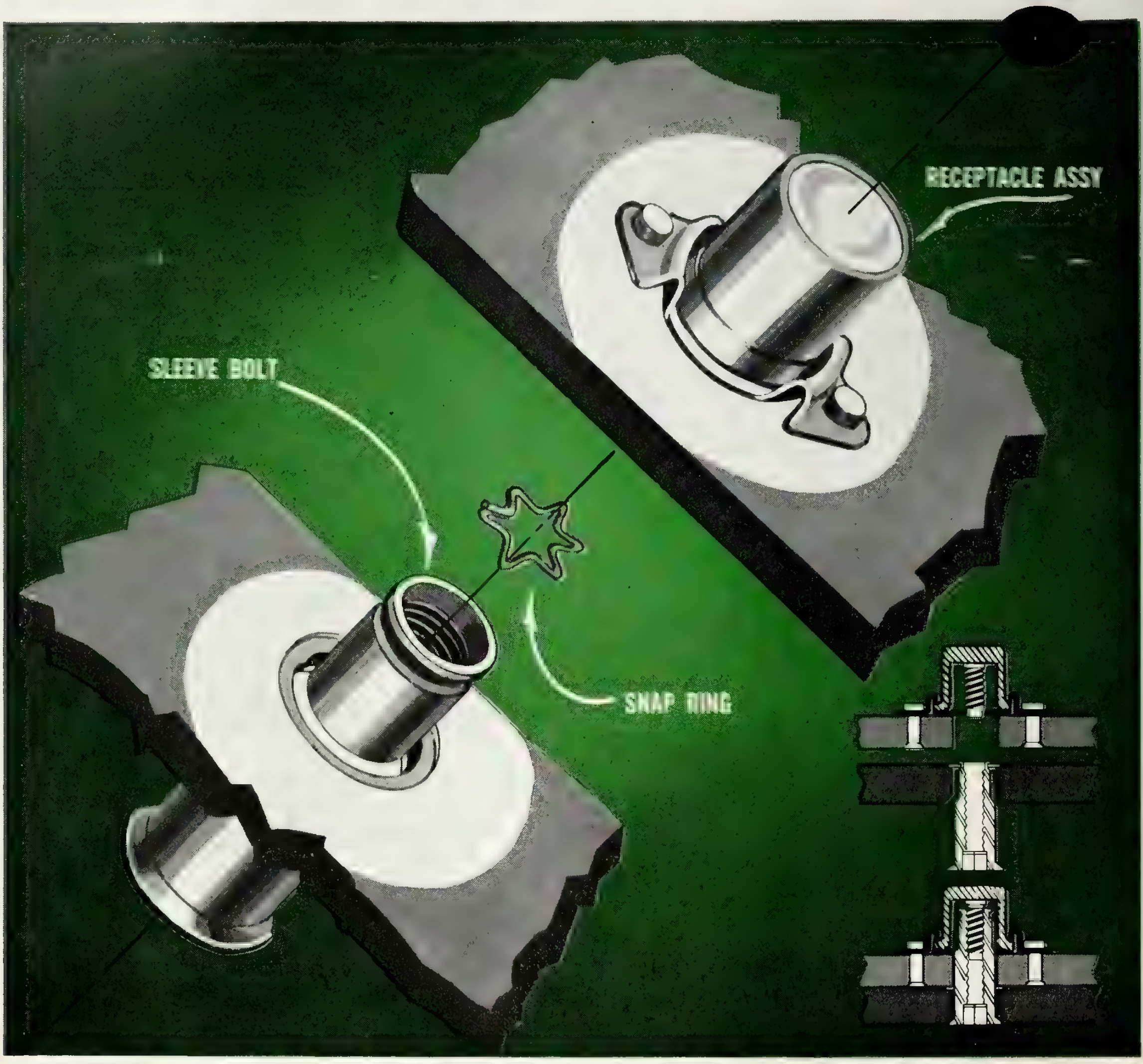

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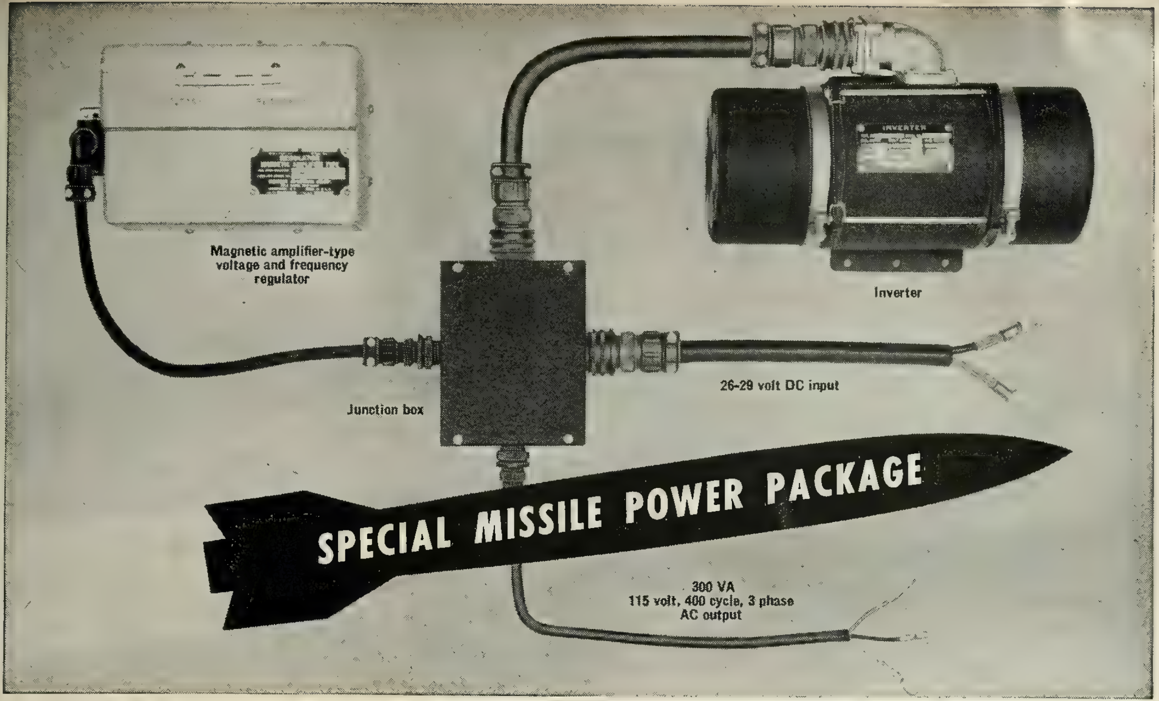
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32B52	27.5	35	115/200	1 3	500 500	40,000	25	—
32B106	27.5	95	115	3	1400	35,000	44	—
32B27	27.5	285	115/200	1 3	3500 4000	50,000	76	—

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	Volts	Amps.	Volts	Phase	VA Rating			
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12126	27.5	2	26	3	10	35,000	2.3	E1615
MG-54	27.5	22	115/200	1 3	250 250	50,000	17	E5109
12142	27.5	22	115	1 3	250 250	35,000	13	E1617
12143	27.5	22	115	3	250	35,000	13	—
32E01	27.5	35	115	3	500	50,000	26	AN3533-1
32E00	27.5	51	115	1 3	500 750	50,000	34	AN3534-1
MG-65	27.5	52	115/200	1 3	750 750	50,000	35	E52805-2
MG-61	27.5	126	115	1	1750	50,000	54	53C6767
1518	27.5	126	115	1 3	1500 1800	20,000	37	—
32E06	27.5	160	115/200	1 3	2000 2250	50,000	56	E1725
32E03-3	27.5	150	115	1	2500	50,000	58	53B6227
32E03-9	27.5	160	115/200	1 3	2500 3000	50,000	58	E54807
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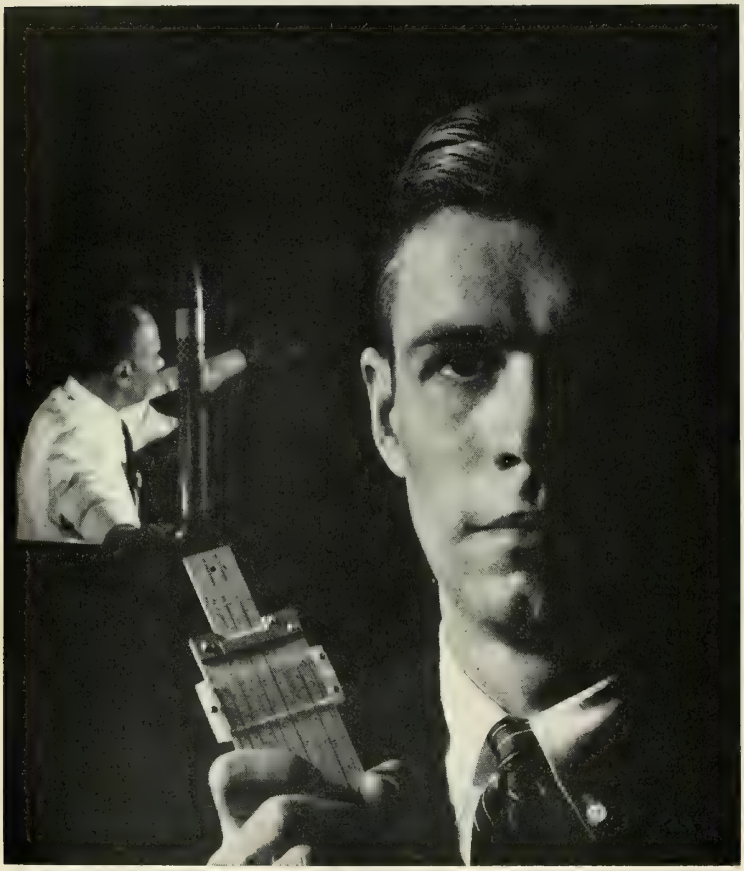

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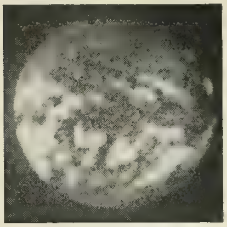
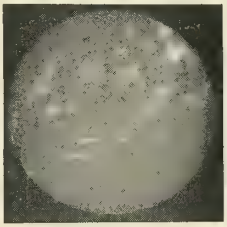
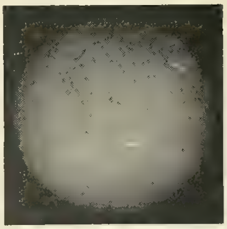
COVER: B-52 has carried *X-15* aloft for second time for aerodynamic checkout and crew training.



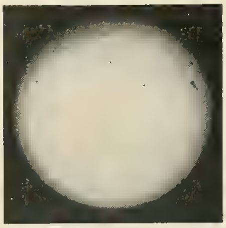
FIRST picture of entire sun taken with light of Lyman-alpha line—fundamental line of radiation . . .



NAVY scientists used special camera in nose of *Aerobee-Hi* rocket fired to 123 mile altitude . . .



COMPARED with ground shots using sun's calcium K light (2), hydrogen red (3) and white (4).



PICTURES give new clues to sun's effect on radio broadcasting and weather on earth.

When Russia Puts Men in Space

Professor Fred Singer, whose series of scientific articles on the effects of nuclear explosions in space currently appearing in this magazine is bringing sharply into focus the real significance of such blasts, also suggests that the Russians are very likely to place a two-man satellite in orbit this summer—and that the U.S. public should be psychologically prepared for such an eventuality.

Dr. Singer, associate professor of physics at the University of Maryland and one of the U.S. scientists who for some years suspected the existence of a radiation belt around the earth before its actuality was verified, said:

"Try to imagine the headline: 'Russians Put Two Men in Orbit.' Not just one; they are capable of putting up two and they know the jolt it will produce on the world. This may happen during the middle of the year. Imagine that these men are able to converse in English, are able to recognize signals from the ground, that they will perform all sorts of functions ranging from broadcasting propaganda to answering questions addressed to them, to reporting forest fires and so on. Imagine this to go on day after day, even at night. It is hard to overestimate the impact, especially with our highly efficient media of mass communication."

Up to this point Dr. Singer is in reasonable agreement with most U.S. military leaders concerned with the space exploration field—that is, that the Russians probably have or soon will have the capability of placing man in orbit and that such a feat would have tremendous propaganda value.

But beyond that point the scientific and military minds do not concur. Dr. Singer feels the man in orbit would have little military significance and tells why. He points out that you cannot "drop" a bomb from a satellite. Since the satellite itself is falling freely in space, the bomb would simply remain alongside and could blow up the satellite. The bomb, he points out, would require a velocity of just about 25,000 feet per second to be launched to a target directly below the satellite, although it would need a lesser force for other trajectories.

Dr. Singer also feels that a space station is a sitting duck. It can be detected, as he points out, by reflected sunlight, by radar or by its own infrared radiation. Its orbit, governed by the laws of planetary motion, can be accurately predicted. And, to be brutal, a manned satellite is vulnerable to the smallest puncture which would destroy its airtight integrity—and most especially it is vulnerable to nuclear weapons. For example, Dr. Singer reports, using data now available from Project *Argus* and other unclassified sources, it can be calculated that a two-megaton bomb produces a lethal radiation dosage of 500 Roentgens over a sphere of 130 miles radius, certainly a menace to a manned space vehicle.

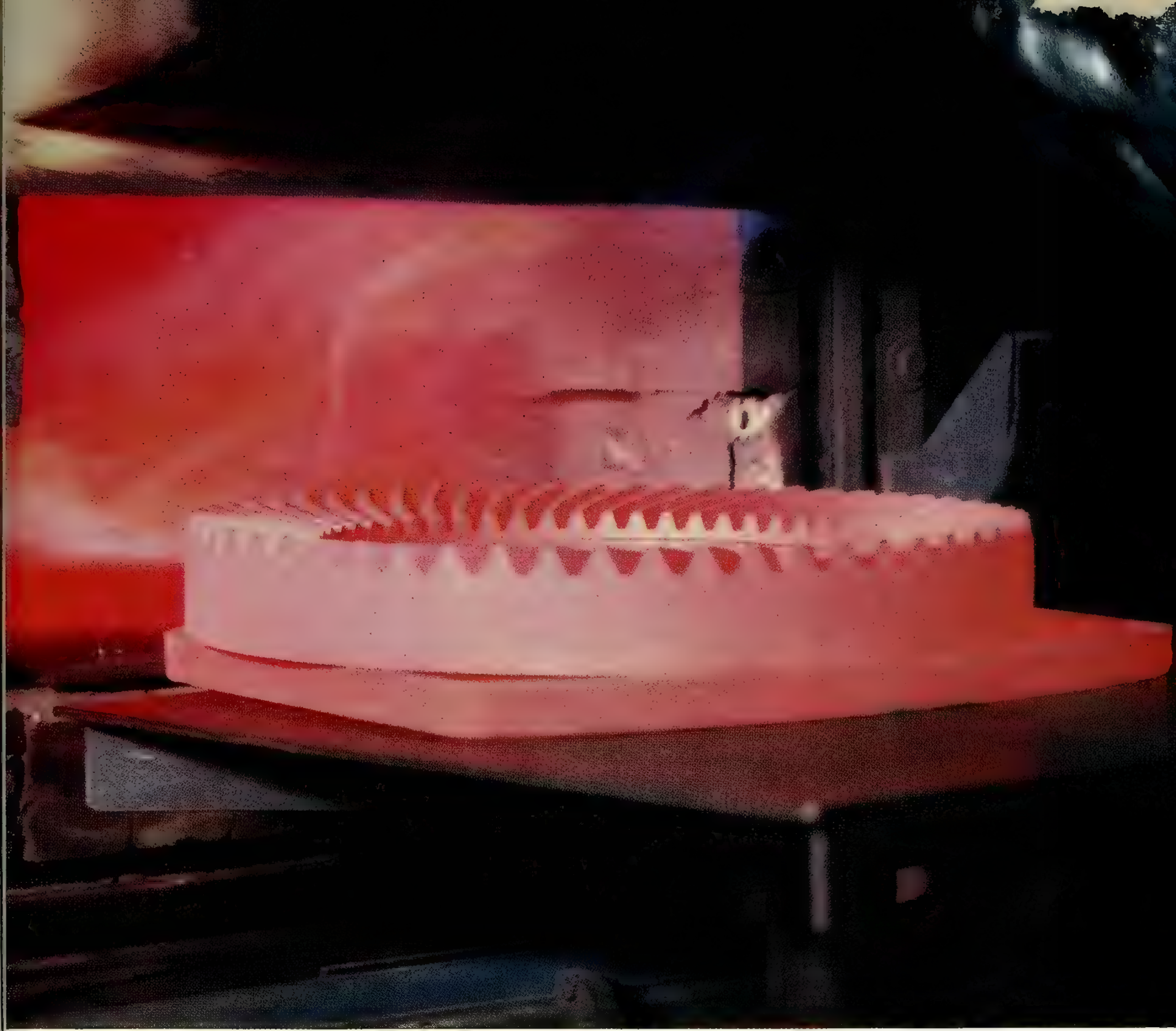
Military men, on the other hand, feel that the tactical value of a manned satellite might be considerable. For one thing, its reconnaissance value, using the human eye and brain instead of a machine, would be incalculable. They think, too, that such a satellite probably would carry sufficient rocket power to change its own orbit and that, contrary to being a sitting duck, it might be very difficult to find indeed—for a time, at least. And finally, that such a satellite might very well carry a launching instrument which could impart the necessary force to launch a small object earthward. With ground vectoring this might be done with great accuracy, sufficient to hit New York City or Washington, perhaps.

Actually, the exact military significance or potential of such a manned satellite at this time makes very little difference, it seems to us. It most certainly wouldn't be used to drop a bomb on New York or Washington, though if it dropped a capsule containing a Russian flag and a bottle of vodka, the propaganda shock would be just about the same.

We live in a world which through several decades now has seen aerial bombing destroy military targets and centers of population. A man in the sky overhead, like the hidden menace of the dark, is instinctively frightening. It is easy to foresee that a manned satellite could be magnified out of all reasonable proportion to its immediate military significance. The public should be told now that such an event is a possibility, and given an idea of what can be expected when it does happen and just what the import might be.

We would like to suggest that the Department of Defense Office of Public Affairs, which frequently is employed to less useful purposes, join forces with our civilian scientific agencies and begin an educational campaign on the significance and immediate military potential of the manned satellite. We think they would find the nation's press media cooperative and it would be a great national service.

Clarke Newlon



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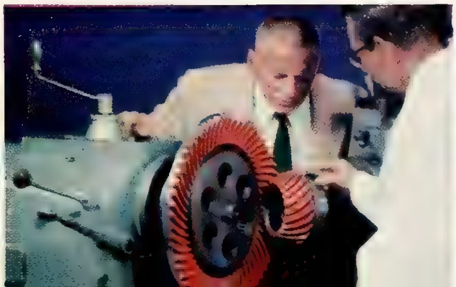

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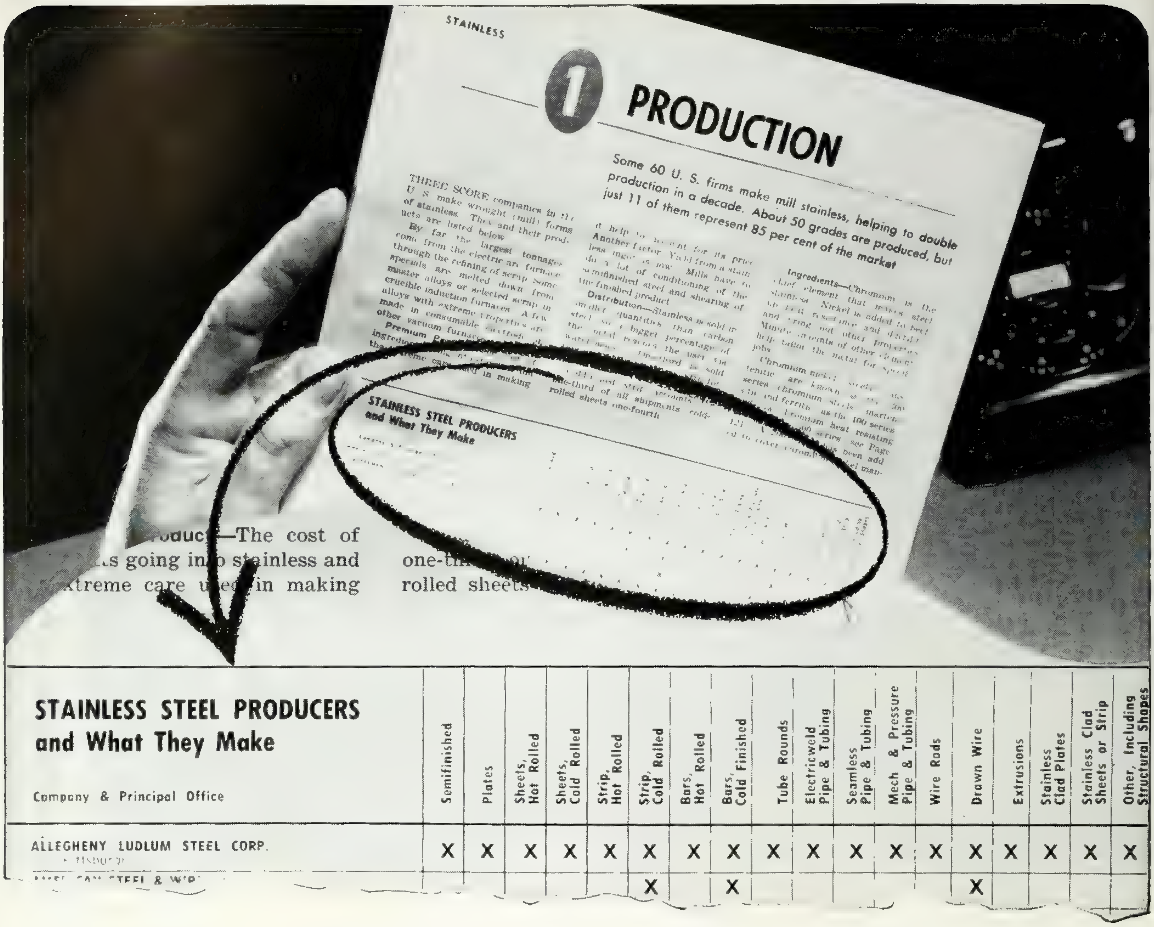

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STAINLESS STEEL PRODUCERS and What They Make

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ALLEGHENY LUDLUM STEEL CORP. Pittsburgh	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
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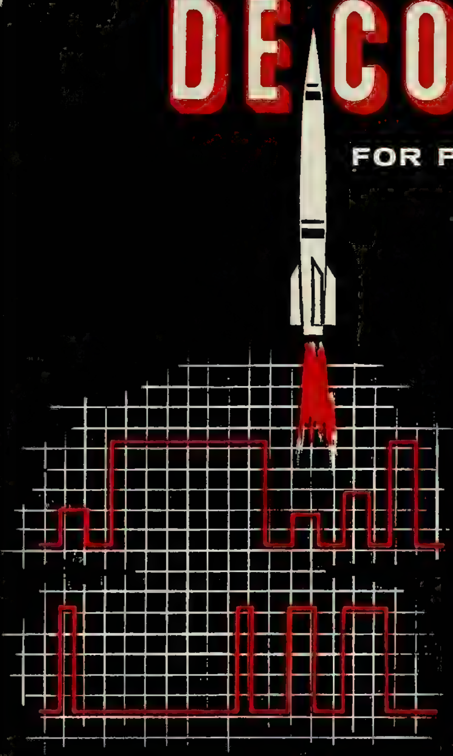

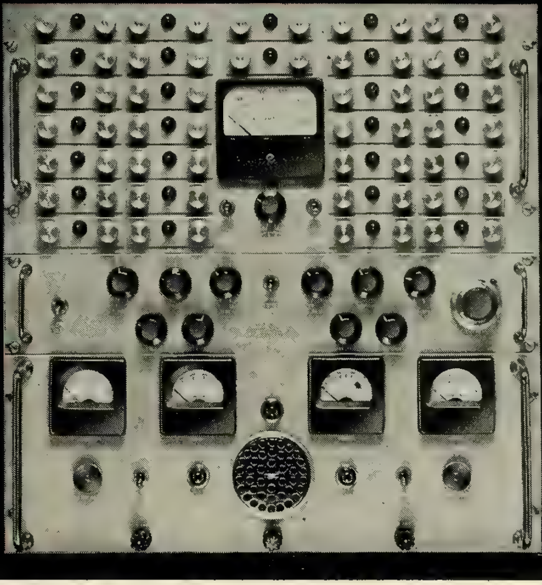

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- Built-in test selector permits visual inspection of waveforms throughout system for quick malfunction detection.
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washington countdown

IN THE PENTAGON

Navy supporters are spreading the word that the *Polaris*-launching submarine will be operational by mid-1960—months ahead of schedule. The Navy has officially said the new missile subs will be operational by the end of 1960.

• • •

Kwajalein—The old Japanese World War II base in the Marshall Islands—will be used as a testing ground for Western Electric's *Nike-Zeus* AICBM. The *Zeus* missiles will be launched against target missiles fired across the Pacific Missile Range from Vandenberg AFB. The Army plans to begin building testing facilities on the U.S.-held island this summer.

• • •

The Air Force is considering stationing its *Atlas* ICBM's in concrete bathtub-shaped bunkers instead of inverted silo-shaped holes as previously indicated. The concrete bathtubs would be covered with steel roofs which would be stripped away to enable the missile to be erected and fired.

• • •

One of the chief topics of conversation at a secret meeting of top Air Force officers on the West Coast is reported to have been expansion of the huge Pacific Missile Range with emphasis on an equatorial launch site.

• • •

The nuclear submarine's latest polar junket appears to have eliminated one major worry of designers of missile-packing submarines. that's communication. The Skate is reported to have been able to receive low-frequency radio signals while travelling near the surface under the polar ice pack. It transmitted radio signals by raising its antenna through the thin ice found between Arctic ice floes throughout the year.

• • •

Project Discoverer is being speeded up. Previously one shot a month was planned. Now the number may be increased to an average of two. The second shot in the West Coast launchings is expected in about a week.

• • •

Dr. Herbert York, has divided his new research and engineering office into five operating systems and seven technical fields. York also will have six other boards, offices and groups reporting to him. However, the organizational chart still gives no indication of York's relationship with his old home—ARPA.

ON CAPITOL HILL

The House Space Committee plans to begin hearings later this month on NASA's proposed half-billion dollar budget for FY 1960. Watch for charges that the new budget is a blind for budget-balancing and for efforts to increase it. Reason: It actually calls for spending less than $200 million in FY 1960—all the rest is to be used as obligational authority.

• • •

The Senate Space investigating Subcommittee headed by Sen. Stuart Symington (D-Mo.) will resume its inquiry into possible duplication of federal space agencies about mid-April. The much-heralded investigation only just began when it was interrupted by the Congressional Easter recess.

AT NASA

The United States may look to the use of a ship to launch a satellite into an equatorial orbit at an early date. Until now U.S. scientists have thought construction of a launching site on some equatorial island would be necessary. But the success of Project *Argus* has opened up the possibility of developing seaborne satellite launchers.

AROUND TOWN

Much of the confusion as to the full meaning of the results of Project *Argus* may be cleared up later this month. IGY scientist are scheduled to make the first formal scientific report on the high-altitude atomic tests at the annual meeting of the National Academy of Sciences.

• • •

Possible meteorite in the wind: Soviet Scientist at the Academy of Sciences at Alma-Ata are working on whether plant life could be transplanted from Earth to Mars. Air Force scientists have done some work along this line at Randolph Field.

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industry countdown

STRUCTURES

Outfitting *Polaris* nuclear submarines with missile launching equipment is reported to be one reason for the new acquisition by Lockheed Aircraft of Puget Sound Bridge & Dredging Co., Seattle. Facility also will be used for ground support and missile-space vehicle development work.

• • •

Readiness of Minneapolis-Honeywell's *Asroc* (anti-submarine rocket) is indicated in Navy request to Congress for $26.2 million. Half would go for 11 shipboard installations and remainder for 86 pieces of *Asroc* hardware.

• • •

Projection by AIA of Pentagon's 1960 FY funding is $2.5 billion for missile R&D and testing and $2.7 billion for missiles going into service use or inventory.

• • •

Look for Navy to make ICBM bid with *Polaris* cluster. New facilities at China Lake, Calif., ordnance station reportedly are being readied for end-of-year tests of *Polaris* boosters (probably clustered in three) for 5000-mile capability. Navy also is reported interested in modified *Polaris* for air-launched ballistic missile.

PROPULSION

New entry in high-energy chemical field for missile propulsion is Celanese Corp. of America, which will apply know-how in polymers and synthetic organic chemicals to solid fuels. Heading up new operation is Julius P. Zeigler, former chief of chemicals, propellants and explosives engineering development for Army ammunition command.

• • •

Hush-hush cryogenic storage insulator will be licensed on non-exclusive basis to industry by developer, National Research Corp., Cambridge, Mass. Insulator is reported to be 15 times better than powder and "twice as good" on performance-to-density basis as best commercial materials available.

• • •

Compressed air "reactor gun" to propel body in weightless space travel is being developed by ARDC. Motion would be controlled by shooting gun in opposite direction operator wishes to move. Tryouts are being in C-131B aircraft flying kaplerian trajectory.

ELECTRONICS

Outlook is for defense spending on electronics maintenance, procurement and R&D to jump from $5.5 billion in FY 1959 to $12.3 billion in FY 1970. EIA expects Pentagon expenditures to total over $100 billion on electronics in next 11 years with big expansion in missile funding accounting for the rise.

• • •

Accustomed to working with detailed specifications, industry is getting new indoctrination in *Pershing* system. In guidance, for example, Eclipse-Pioneer is working on the "submit it for test, we'll give you the specs later" philosophy of ABMA. E-P's guidance system, incidentally, will not go on the first few birds. ABMA will use the time-tested earlier LEV3 by Waste King to insure maximum reliability of initial test vehicles.

• • •

With 1960 FY funds, the Air Force will support two new communications systems tying into the early warning network. They are: CADIN (Canadian Air Defense Integration Network) and BADGE (Base Air Defense Ground Environment) located in Alaska.

• • •

Another round in transistors vs. tubes is shaping up. Eight tube manufacturers have formed Ad Hoc Electron Tube Council. CBS-Hytron, General Electric, Philco, RCA, Raytheon, Sylvania, Tung-Sol Electric and Westinghouse. The founders, say one primary aim is to promote tube use in electronic applications "where they offer superior properties."

ASTROPHYSICS

Nomination for first moon "man" is General Electric's "Handyman"—electro-hydraulically operated robot. Has "human" grasp so deft it can pick petals from flowers. Used in radioactive work, GE says "Handyman" would respond to remote control over 238,000-mile distance to Moon.

• • •

More data on *Argus* will be forthcoming April 27 when IGY group at NAS reveals first results of *Explorer IV* program which monitored high altitude atomic explosions.

• • •

Before *Argus* was known officially by that name, Lockheed reports its workers had nicknamed the project "Black Angus." Argus is the name for a 100-eyed Greek monster.

More about the missile week on page 16

engine power

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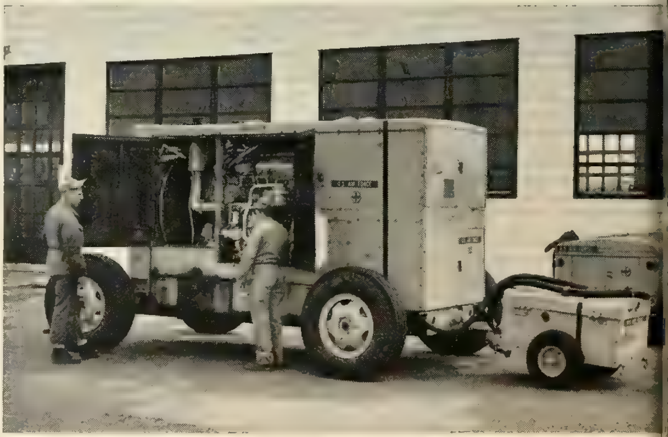

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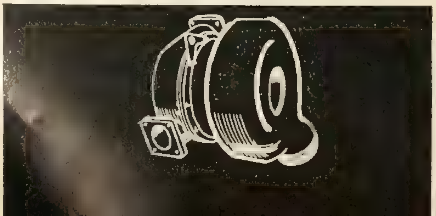
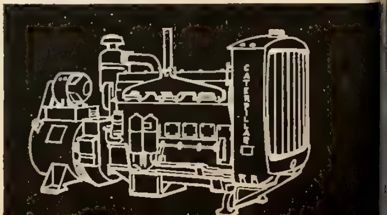


SIMPLE—Caterpillar Electric Sets for both primary and standby power are dependable, easy to operate and need little electrical equipment.



APRIL 6, 1959—VOL. 5, NO. 14

missiles and rockets

MAGAZINE OF WORLD ASTRONAUTICS

Weapon System Concept Faces Trial

House group is set to quiz industry and Pentagon spokesmen in lengthy hearings airing charges of monopolization and profiteering

by Jim Baar

WASHINGTON—A hard-hitting House subcommittee is about to begin the most intensive investigation so far of the system under which private industry is being granted stewardship over developing the nation's missile arsenal and other advanced weapons.

The results could have far-reaching effects on industry, government, the nation's security and the future of U.S. space exploration.

Nearly a half-dozen bills already pending in Congress are aimed at either supporting or undercutting the growing use of the weapon system concept of military procurement. Any final action on them appears fairly certain to await the investigation's outcome.

But the interest of Congress in military procurement methods is rapidly increasing.

The House Armed Services Investigating Subcommittee headed by Rep. F. Edward Hébert (D-La.) will open its inquiry April 13 with testimony from officials of Lockheed and North American. Next on the schedule: Boeing and Martin.

In all, more than a dozen of the nation's major defense contractors are expected to be summoned to testify along with smaller firms. Tentative plans call for summoning government officials next.

• **Probe's purposes**—The investigation—scheduled to run through July—is aimed at determining among other things whether the weapon system concept has resulted in:

• Abdication by the Pentagon to a few industrial giants of true control of procurement.

• Squeezing out of competition and increasing monopolization of the market.

• Profiteering through arbitrary award of subcontracts to subsidiaries.

Moreover, the investigators plan in the course of their work to lay open for public inspection the tangled Pentagon forest with its many byways for contractors seeking military contracts.

The subcommittee staff began work on its investigation a year ago after receiving complaints from both large and small contractors charging abuses. It has received many more since then.

• **Concept assailed**—Meantime, a number of Congressmen have attacked the weapon system concept with increasing vehemence. They have charged that the Pentagon is resorting less and less to competitive bidding. And they contend that as a result millions of dollars in tax dollars are being wasted —or worse.

Also, two Congressional subcommittees already have investigated various aspects of the weapon system concept.

Hearings by the House Military Operations Subcommittee into management of the Air Force ICBM program by the Ramo-Wooldridge Corp. are expected to conclude this month.

However, none of the investigations so far has approached the matter in as sweeping a manner or has aimed at as much completeness as the forthcoming Hébert investigation.

• **Sample questions**—As a start, the Hébert subcommittee has sent all scheduled witnesses a format of questions that they should be prepared to answer.

It includes such questions as:

• What kind of contracts do you grant to subcontractors?

• Are they negotiated? What is the competitive situation?

• Do you take technical proposals?

• How do your subsidiaries participate in seeking subcontracts?

The subcommittee plans to move ahead slowly, carefully studying all testimony before proceeding to each phase of the investigation. The investigators are fully aware that any charges that may be brought out must be capable of standing up against the strong arguments of weapon system advocates both in industry and the Pentagon.

• **System's defense**—The Air Force —the most ardent admirer of the weapon system concept—began adopting it about five years ago. Since then its use has spread and flourished until today it is the dominant method used in one form or another throughout much of the military services for development of advanced weapon systems.

From the beginning it was designed to combat one of the greatest evils of military procurement: failure to have all the pieces ready to put together at the right time.

Such failures in past years were legion. Sometimes they were merely funny. Other times they were nearly disastrous.

Former Defense Secretary Robert M. Lovett once said the failure of many needed planes to arrive in Korea early in the Korean War was caused by the lack of a sufficient number of one particular 25-cent part.

The planes were built by one contractor. The Pentagon had contracted with another manufacturer for the 25-cent part.

Weapons system advocates contend that with today's ever-more-complicated weapons there is greater and greater need for a procurement method under which all the parts arrive on time.

Public hearings open April 27 before the House Ways and Means Committee on a 27-month extension of the government's authority to renegotiate defense contracts to recapture any excess profits. In asking extension, Defense Department proposed a change which would allow contractors to keep savings resulting from cost-cutting economies by requiring renegotiation board to take this into account. Another change would provide for judicial review tax courts decisions in renegotiation cases.

Better observation of the universe from the Southern Hemisphere is the aim of an observatory to be set up near Santiago, Chile, by the universities of Texas, Chicago and Chile. Dr. Gerard P. Kuiper, chairman of the University of Chicago astronomy department, is head of the cooperative project.

Boeing's better-than-400 nautical mile range Super *Bomarc* interceptor is under contract negotiation for continued development and manufacture. More than $100 million of original $300 million contract has been spent, Boeing says. It calls for production of only a limited number of *Bomarcs*. Static and flight tests are scheduled soon.

Government contractors will have access to a new $200,000 "Tom Thumb" metals extrusion and forging facility for experimental production of space materials at Wright Air Development Center, Dayton. Plant has high vacuum consumable electrode arc-melting furnace of 6000 amphere capacity, 8-inch sheet capacity rolling mill and 600-ton extrusion press.

Financial reports: Boosted by a quadrupling in volume of missile-space work, Lockheed Aircraft Corp.'s 1958 net profit rose to $18.5 million on record sales of $968 million. In 1957 profits were $16.3 million on sales of $868 million. End-of-year 1958 backlog was $1.156 billion—10% less than 1957 unfilled orders of $1.280 billion.

At $1.511 billion, 1958 sales of General Dynamics Corp., fell off the 1957 peak of $1.562 billion. Net earnings were $36.7 million compared to a 1957 net of $44.2 million. However, the company's estimated backlog at the beginning of this year was $2.095 billion—up considerably from the $1.75 billion of orders a year previously. Additional contracts under negotiation totalled $645 million.

Northrop Corp.'s earnings of $3.1 million for the first half of the year ending Jan. 31 were up from the same period of a year ago, despite a drop in sales to $116 million. The corresponding 1957 net was $2.8 million on income of $125.5 million. Unfilled orders of $264 million were up $22 million from the close of the last FY on July 31, but down from the Jan. 31, 1958, backlog of $275 million.

Record sales and earnings gave Chance Vought Aircraft a 40% improvement in 1958 over the previous year. Sales were $333.2 million and earnings $8.9 million against 1957 sales of $237.3 million and net of $6.1 million. The company's end-of-year backlog was $370 million with cancellation of the Navy *Regulus II* program clouding the outlook for 1959 somewhat.

Bell Aircraft Corp.'s net of $4.7 million was 9½% above 1957 on sales of $182.8 million. The sales figure, however, was 9½% below 1957 sales of $202.2 million.

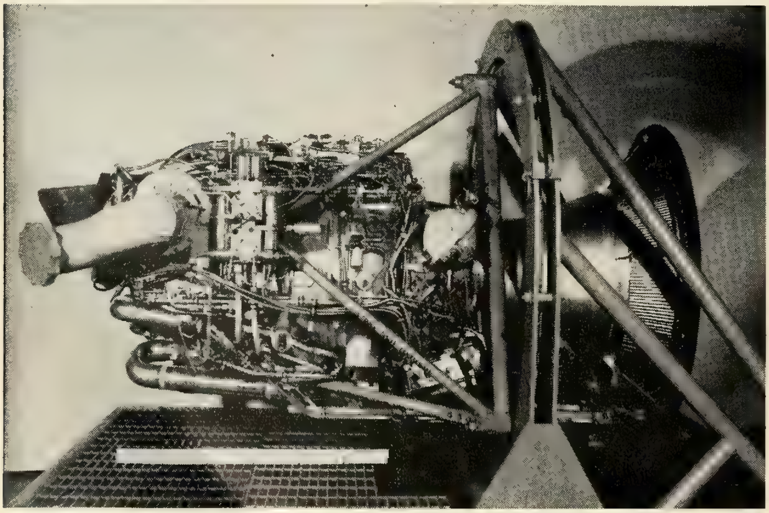
Marquardt is emphasizing that it is not lining up with any specific company in the TR-101 (*Penny, Hilo* drones proposal, *M/R*, Feb. 23, p. 21). Marquardt's customer relations department sent telegrams to industry contacts saying that it furnished propulsion information "to many companies" during proposal activities but that it "has not joined forces exclusively."

In manned space flight, how good is "reliable?" J. M. Wuerth of North American's Autonetics Division says to make the odds 1000-to-1 to return alive from an 8½-month trip to Mars in a spacecraft with 10,000 critical components, the Mean-Time-Between-Failures of the components must "exceed 7 million years." Individual components would not have to last that long, but the rate of failure can not be more than one out of 7 million parts in a year's time.

The AF has recovered data capsule ejected from a *Thor* nose cone. Test March 26 at Cape Canaveral established "reliability and accuracy" objectives on 1,600-mile flight. Eighteen-inch plastic capsule contained instrumentation to record atmospheric friction on 15,000 mph plunge back to earth.

The sequence of rockets to be used in testing out Project *Mercury* before the capsule actually goes on top of an *Atlas D* is: *Little Joe, Redstone,* and the *Jupiter.*

Gladding, McBean & Co. makes it clear description of 97% and 99% pure alumina for fabricating missile radomes (*M/R* March 16) has no connection with *Sparrow III* radomes. Reference to alumina was to illustrate the type of high-purity oxides which may be used in new GMB fabricating process.



UNDERGOING extensive testing is Reaction Motors 50,000 lb.-thrust liquid rocket engine for the *X-15*. The engine can be started, throttled, shutdown and restarted without endangering the pilot under any single malfunction.

A Hard Look at Space Logistics

AF-sponsored conference told it may be 5-10 years before man can be kept alive in space; planners banking on better component reliability

by William O. Miller

WASHINGTON—The cost of ground support equipment in the final analysis probably will be the limiting budgetary consideration in development of the U.S. program for the exploration and exploitation of space.

This is the current thinking of top Air Force planners—a conclusion reached at last fall's Space Logistics conference at Maxwell AFB (M/R Oct. 6, 1958), a report on which was released to *M/R* this week.

At this meeting, key AF personnel huddled with representatives of industry and other government agencies to "get a feel for the future so that we can better anticipate the problems," as Brig. Gen. L. B. Kelley, AF Director of Logistics Plans, put it.

Only an expansion of present logistics and supply systems is expected to result from growth of the ICBM and IRBM programs. But many basic changes are foreseen as man moves into space. These involve modifications in estimates of requirements, funding, procurement and procurement lead time, production, packaging, transportation, storage and special handling techniques.

AF planners are looking to an advancement in component reliability to reduce or even eliminate a number of peculiar and common type items in the requirement area with accompanying reductions in procurement funding, storage etc. They point out that initial supply may have to be provided in one complete package in consonance with reaction time—without the re-supply effort (follow-on) and consequent delays through requisitioning, accounting and shipping actions.

The more exotic systems will bring the new high-energy propellants to the fore, and additional problems will develop in production, storage, distribution and handling. Hence it is believed necessary to build up production capacity to keep abreast of technical developments. Special handling techniques and specific type tanks or containers will be required because of the corrosion, radiation, refrigeration and toxic aspects of these propellants.

To point up the critical nature of this problem, one spokesman said that a severe shortage of liquid oxygen caused a seven-months delay in the development of the rocket engine for the *Navaho* missile booster.

The choice of ground-based tracking stations poses many problems and probably will be aimed at utilization of existing facilities—commercial or military.

• **Water-borne launch sites?**—Modified aircraft carriers may find a new use as mobile water-borne launch sites. The major consideration here is not only to optimize the mission requirements: with the advent of nuclear power plants, sea-borne launch sites would minimize the problems of radiation and decontamination.

AF thinking was geared for the purposes of this 10th annual seminar to the idea that the first-stage booster for launching space vehicles is considered part of the ground support equipment. Those attending the seminar pointed out that for reasons of economy these boosters are apt to take the form of gigantic, air-breathing, manned vehicles operating at Mach 4 speeds and requiring a continuing supply support system similar to that envisioned for the B-70 weapon system.

They added that while chemical boosters should present no problems technically, the vehicle and the propellant would have to be larger.

• **Maintenance puzzles**—Maintenance problems are enormous—whether the plan calls for repairing and replacing parts while the vehicle is in orbit, or bringing it back to earth for such work.

Since more than 70% of the hardware at a fixed launching site is ground support equipment, it was argued that the specification, design, development, production, standardization and maintenance of such equipment should receive the same emphasis as the vehicle. These developments must be carried out concurrently with the space vehicle and be compatible with it.

Extensive training programs should be developed for each piece of peculiar or special equipment. Each space vehicle will require special clothing and handling characteristics. The use of exotic fuels will make it necessary to learn how to live with and handle their toxic, corrosive, storage and instability effects.

The report calls reliability the paramount requirement for space ship design, not only because it will determine success or failure, but also because we refuse to consider man as an expendable item, and because we find that the cost in dollars of unreliability in space vehicles is almost fantastic.

Reliability in the 95-98% bracket must be obtained for space vehicles, the report says, and this will be accomplished not by evolutionary design improvement, but only by revolutionary change in design philosophy. The cost per pound of orbiting equipment or personnel has been estimated at $1000. Failure of a 5¢ item could cause destruction of a 500-pound unmanned satellite representing a half-million dollars. It would cost $10,000 to deliver a 10-pound spare part to a vehicle or the moon.

• **Maintainability**—Another important design consideration is maintainability, determined to a large degree by the design of the vehicle. Accessibility is the most important factor for in-flight repairs. Removal of one component should not involve removal of other components—quick disconnects, button fasteners or other easily operated devices will aid here. Parts should be standardized to the maximum, even to the smallest subassembly or part.

New concepts will have to be developed also in the area of post-launch maintenance of manned or unmanned satellites, or moon stations. These will be based on reliability, automatic systems and functional checking by remote control, some duplicate circuitry with automatic or remote-controlled switching from a faulty circuit.

Maintainability also would be enhanced by restricting satellites during early years to a single major purpose.

• **Weakest link**—The report said it appears that a fully automated, completely reliable unmanned weapon system will have been achieved at least concurrently with the achievement of a man-in-space vehicle. Despite more optimistic predictions, a paper presented at the seminar by Col. C. H. Roadman provided an R&D schedule (see timetable) indicating from five to 10 years work will be required before man can be kept alive in space.

Under ideal conditions, equipment and supplies for one man in space for seven days totals 283 pounds. This, Col. Roadman said, can be compared with a 707-pound requirement using presently available equipment and methods.

Man, Col. Roadman said, will be the weakest link in space travel, and engineers must adapt their plans to the unavoidable requirements of the human organism. The cabin must be a "terella"—a synthetic little earth. Another spokesman coined the term "man-unit," which can be defined as a man and the consumables he will require for the duration of his mission in space, as the principle of personnel transfer.

• **Moon base**—A manned lunar station might serve as (1) an observation post, (2) a weapon system platform, or (3) a forward "base in space," according to the report.

Phase I of a program to establish a base on the moon would be an orbit around the moon and probe landings—no manned landings. Phase II, during which first landings would be carried out, is considered most hazardous. It consists of supply support for landing, erection and equipping of a lunar station. Advance planning should stress engineering design and development of lightweight equipment without sacrifice of durability and ease of erectability. Regeneration systems must be provided to utilize all types of waste and algae systems for food supply.

Generation of breathing oxygen and atmosphere from metallic sources and electricity through solar energy must be developed. It is assumed that solar or a lunar source of energy will be available for such devices as an electric catapult and return transportation from the moon when the lunar base reaches an operational phase.

Preceding the operational phase, for which scheduled periodic trips and supply support are contemplated, AF planners see a third phase during which the first landings would be exploited and the moon explored. Supply during Phase III would be from the initial package and from unmanned vehicles.

• **Problem areas**—It is suggested that investing comparatively few dollars now on engineering items for lunar occupancy, dynamic mockups to determine weak links and "single managering" logistics support could keep the costs and economic problems within relative percentage limits:

Survivability and cost—Maintaining one man as opposed to a number with various skills must be studied to provide a maintenance concept.

Stockpiling—Large quantities of certain fuels and materials must be considered in the national policy.

Reliability—An unbelievable level of reliability is needed to insure low cost and low re-supply requirements.

Data processing—Communications and computer operations must be positive and accurate to insure availability and shipment of correct items.

Inventory—Excessively large inventories are inevitable if standardization of nomenclature and use of "off-the-shelf" hardware are not enforced.

Concurrent development—Problems can develop if there is not concurrent development of support equipment, supply techniques and a supply system for lunar operations.

Another conclusion reached was that we have yet to determine the exact nature of the military requirement for human occupants in earth orbiters. If this requirement does not materialize, the report says, the supply support aspects are reduced to "throw-away-and-replace" as opposed to fix-in-orbit or recover-repair-and-relaunch.

• **Recommendations** — Recommendations of the seminar were:

1. That space vehicle design stress self-sufficiency, convertible equipment or multiple uses of equipment, miniaturization and weight reduction for subsystems.

2. That qualified logisticians be incorporated from the beginning into teams developing new space activities.

3. That basic design of frames and components for unmanned satellites be standardized, with separate kits installed specialized missions.

4. That satellites be restricted to single major purposes during early years.

5. That operational manned space activity not be undertaken until the requirements for manning have been demonstrated conclusively and human beings have been tested adequately in a real space environment.

6. That the technical and professional competence of military personnel be further raised, that skill needs be spelled out earlier, and that use of skills be more closely controlled.

7. That terrestrial space facilities normally be sited in areas already owned by the government and most compatible with future space systems growth, rather than with current approved plans, and that space facilities be designed with nuclear devices in mind.

8. That since space programs for many years to come are likely to emphasize quality rather than quantity, logistics arrangements be tailored accordingly.

R&D TIME TABLE NECESSARY FOR KEEPING SPACEMAN ALIVE

ACCELERATION	Up to two years' study is needed on human performance under g-forces and protection from g-forces.
WEIGHTLESSNESS	Four or more years will be required for studies, and only limited studies can be made until a suitable test bed is available for long-duration studies.
THERMAL EFFECTS	Up to three years will be required for chamber, vehicle, and performance studies.
WATER, NUTRITION, AND WASTE DISPOSAL	Up to five years will be needed for studies, which will include development of regenerative, carbon, and nitrogen cycles.
RADIATION	Up to two years will be required once a recoverable orbiting satellite is available.
ESCAPE	Up to two years will be required following determination of feasibility of escape.
ISOLATION AND CONFINEMENT	Five to ten years will be needed to overcome deficiencies discovered and a test vehicle will be needed.
PRESENTATION & PROCESSING OF INFORMATION	Up to five years will be needed for laboratory and substantiating flight tests.
CREW SKILLS, SELECTION AND TRAINING	Up to five years will be needed to determine requirements and to select and train personnel.

BRITISH ASTRONAUTICS

- ***Laport using new HPT manufacturing process***
- ***BLACK NIGHT resignations protest lack of policy***
- ***Speculation on high altitude radiation reports***

by G. V. E. Thompson and K. W. Gatland*

LONDON—The British Firm of Laporte Chemicals Ltd. has started manufacture of high-test hydrogen peroxide (HTP) at their new plant at Bayonet Works, Warrington, Lancashire. They are using a new process developed by the company's R&D department at Luton, Bedfordshire.

Laporte have previously made peroxide at their Luton works by electrolysis of a solution of ammonium sulphate and sulphuric acid, to give ammonium persulphate solution, which was concentrated by evaporation, heated in a packed tower, and the hydrogen peroxide released removed as vapour.

In the years since the war, increasing interest in hydrogen peroxide has resulted in considerable research on large-scale manufacturing methods, particularly those not dependent on electric power supplies. Most of the work has been concerned with autoxidation of organic intermediates, and the new Laporte process is of this type.

The intermediate chosen is 2-ethyl anthraquinone. It is used in solution in a mixture of an aromatic hydrocarbon and a cyclohexyl ester, solvents respectively for the quinone and the corresponding quinol. The first stage of the process is catalytic hydrogenation in a vertical vessel, and the catalyst (palladium on a granular support) is in suspension in the solution.

After filtration and cooling, the reduced solution is fed to the base of another reactor, where it is oxidized by a stream of air in concurrent flow. In this reactor, the 2-ethyl anthraquinol formed by reduction of the quinone is oxidized back to the original substance, and hydrogen peroxide is produced in the process. No catalyst is needed.

The hydrogen peroxide is removed from the organic solution by aqueous extraction, and concentrated by vacuum distillation. Stabilizers and corrosion inhibitors are added and the organic solution is recycled.

This process was first studied in Germany before World War II, and I.G. Farbenindustrie built a pilot plant at Ludwigshafen. Laporte's plant is the largest of its type in the world. After the preliminary design of the plant had been carried out, information about its operating characteristics was obtained by setting up a representation of the process on the E.M.I. EMIAC I analogue computer.

The investigation was done as a joint project of Laporte and E.M.I. (one of the leading British electronic firms). The EMIAC computer was originally designed for work on guided missiles.

Laporte's plant cost nearly $7,000,000 and will double the company's output of HTP. Rocket motors using HTP as propellant have been designed by the de Havilland and Armstrong-Siddeley companies.

• **Rocket experts resign**—The British rocket and aircraft industries have been shocked by the resignations of P. H. Leyton, chief rocket development engineer to the firm of Saunders-Roe Ltd., and Maurice Brennan, the company's chief designer.

Leyton, who was in charge of development of the *Black Knight*, Britain's most advanced rocket to reach the firing stage, joined Saunders-Roe in 1956; Brennan, whose resignation closely followed Leyton's, had been there since 1936.

The *Black Knight* project has been very successful so far (see M/R, March 2, p. 31) and surprise was voiced when Leyton's resignation was announced. He leaves at the end of March, but is not remaining in the astronautics industry. He will become director of engineering at Black and Decker Ltd.

Because of widespread interest, Leyton sent a letter to The Times of London explaining his reason for leaving the *Black Knight* team—the absence of an official policy on space research. He said that this lack set an insurmountable handicap.

Nevertheless, Leyton noted, to find that despite satellites orbiting the earth and passing the moon and despite the *Black Knight* successes there is still no official space research policy indicates "an official lack of understanding which is proof against the most ardent technical ardour."

• **Second successful launching**—The second *Black Knight* ballistic rocket was successfully fired a few days before Leyton's resignation. As before, it was a night firing at the Australian rocket range at Woomera. An altitude of about 350 miles was reached, and all the instrumentation operated successfully.

• **Whose particles?**—The recent suggestion by Russian radiation experts I. Shklovskii and V. Krasovskii that the high-energy particles trapped in the earth's magnetic field in the inner Van Allen belt are the result of high-altitude nuclear tests was at first dismissed as propaganda.

With the disclosure by the New York Times of the high-level explosions made in U.S. tests, some British circles are now wondering whether the radiations detected by the *Explorer* satellites before these U.S. tests may not be due to atom bombs exploded by the Russians at high altitudes *before 1958.*

There is no evidence that the Russians have done this; on the other hand, even in 1957 they possessed rocket vehicles capable of undertaking the task. Another question being asked is whether the U.S. tests were in fact as secret as was made out, since *Sputnik III* was well equipped for radiation measurements.

** M/R's contributing editors in the United Kingdom. G. V. E. Thompson is editor of the Journal of the British Interplanetary Society. K. W. Gatland is an aircraft design engineer and author of scientific books.*

VANGUARD TESTING:

Backbone of Present Ballistic Missile Art

Check-out 'primer' developed by Martin gives pattern for industry to follow

by William E. Howard

BALTIMORE—In the rapidly-evolving art of pre-flight testing big rockets, concepts originated by the men who put together *Vanguard* today are helping cut critical months from the operational readiness of U.S. ICBM's.

Basic procedures laid out by Martin Co. engineers have set the pattern for improved techniques speeding up the check-out of *Titan, Atlas* and other big missiles.

Refinements have long since dated the pioneer work. But the *Vanguard* test "primer" is so valuable that only now has its step-by-step procedure been declassified—and then only in outline form. These outlines have been made available to M/R.

Meyer Borghese and Bart Wong, who prepared the outlines, make it clear that Martin was forced to develop a test philosophy adapted to the hurry-up timetable for the U.S. satellite program. Pressure was increased with the launching of *Sputnik*.

Accordingly, to reduce field testing to a minimum, Martin established a program to demonstrate, as fully as possible, system performance and integrity before delivering vehicles to Cape Canaveral. This meant that most of the testing would be done at the Martin plant in Baltimore.

• ***Viking* verticle tests used**—To achieve their objective, *Vanguard* engineers borrowed a book from the past—an idea for verticle testing conceived 10 years ago by another Martin engineer, Preston Layton, when he was field manager of *Viking* at White Sands, N.M.

Layton, now head of the Princeton University propulsion lab, had constructed a gantry to determine whether *Viking* gyros and other components would behave in ground tests as well standing up as they did lying down.

Vanguard engineers decided the same type of facility would speed check-out of their vehicles. So they erected at Baltimore a seven-story tower, resembling a grain elevator, which can hold two completely assembled three-stage rockets simultaneously. This was to become the key test "tool."

The 29 x 37 x 97-ft. monument to Layton's idea is constructed of heavy steel and enclosed by sheet steel and fibreglass. It has five working levels spaced at instrumentation sections of the rockets. The levels are completely equipped with power, heat, water and a communication and public address system. An outside two-ton crane handles the delicate job of hoisting the vehicles into the facility and fits the stages together.

• **Shakes and gusts**—In the tower, the "birds" are subjected to complete dynamic tests to verify pre-design analysis. The assembled vehicles are suspended in air and shaken in the "free-free" (in flight) and cantilevered (erected on launching stand) with the propellant tanks filled to different levels to measure bending deflections.

Structural tests simulating aerodynamic and wind gust effects are conducted in a separate tower nearby. Full scale models are constructed for these checks.

Wong, who was senior engineer of the guidance and controls group until leaving Martin recently, says the overall test approach "permitted, to a large extent, the combining of development tests with manufacturing tests, thus allowing for the de-bugging of an advanced improvement in the state-of-the-art system under the direct supervision and guidance of design engineers."

• **Long, tough chore**—How many man-hours go into the complete functional testing of the myriad complex components in each of the 72-ft. *Vanguards,* the Martin men don't say. However, Borghese, who is mechanical department group engineer, concedes it is a "long and complicated task" requiring about six weeks.

Precise instructions for test technicians govern almost every moment of this time, from the day manufacture is completed until the firing switch is closed sending the bird on an orbit-placing flight that takes just 10 minutes. In addition, there are detailed procedures for practically all operations performed by the field crew, including erecting the rocket on its launching stand.

• **Horizontal tests first**—A step-by-step closeup, as described by Borghese and Wong, starts with the first and second stages being wheeled out of the manufacturing plant. While on their dollies, horizontal testing of each system is performed.

Equipment utilized includes: a rocket test console consisting of a fire panel, gyro monitor, controls monitor, controls tester, signal generator and scope panel and junction box; first- and second-stage functional test console; first- and second-stage firing simulator; ground service panel; igniter simulator; jet control box; first- and second-stage grid and pointer; gyro simulator, and gyro tilt table.

All the equipment supplies pressures and voltages to the rocket systems and indicates their reaction to stimuli on lights and meters.

Tests are applied to the first- and second-stage hydraulic and control systems; the first, second and third-stage separation systems; range safety and tracking equipment; first and second-stage propulsion system control units, circuits, solenoid valves, pressurization and propellant systems; and alignment of the first and second-stage thrust chambers.

• **Compatibility tests**—Once horizontal tests are completed, the three stages are assembled in the verticle test tower. Here "acceptance" tests are initiated to assure complete compatibility of the interconnected systems of the entire rocket. They include: spin mechanism clearance—third-stage; third-stage alignment; first and second-stage controls system; rocket electrical systems; radio interference tests of range safety and tracking systems; propulsion system marriage test, and cut-off, destruct and separation systems tests.

Again the rocket test console and other equipment used in the horizontal tests are employed in the verticle test tower. Alignment of the three stages is also accomplished.

• **Second-stage tank pickling**—When this series of verticle check-outs is completed, the first stage is removed and placed on its dollies and the WIFNA tank of the second stage is pickled.

Pickling is intended to prevent excessive scaling which may clog the mesh filters during flight, causing reduced performance or premature cut-off of second-stage burning. Borghese gives this pickling formula: The tank is filled with a 6% WFNA solution comprised of 205 gallons of demineralized water and 9 gallons of WFNA (MIL-N-7254, Type 1) per pickling cycle of 8 hours. After draining it is flushed three times with an inhibiter consisting of 70 GM of sodium dichromate and 180 GM of sodium acid phosphate in 1500 ML of demineralized water. The tank is then flushed with 205 gallons of demineralized water.

The entire process is repeated as necessary until a "specified" drop in size of scales is obtained.

As soon as pickling is completed, the entire missile is delivered to the government for shipment to the Cape. On arrival, the entire series of horizontal tests is repeated to determine if any components were damaged in transit.

• **Second-stage static firing**—The next step is a static-functional test, including static firing, of the second-stage propulsion system. This test, performed on the launch pad, is designed to simulate an actual flight and demonstrate correct functioning of all sequential operations from first-stage cut-off through third-stage spin-up and separation.

During this test, first-stage operation is simulated, along with third-stage spin-up, ignition and separation. The control system is operable, however, with servo packages installed.

A 240-minute countdown precedes the simulated lift-off of the first stage. Then it proceeds for another 620 seconds to represent the actual *Vanguard* flight into space.

Engineers and technicians at this point are in the nearby blockhouse monitoring the "flight" for proper functioning of all components. At the test's completion, if all runs smoothly, the second-stage is put back on its dollies while the first stage is placed on the pad. Then the second stage is hoisted on top and spliced to the first stage with six explosive bolts.

The first stage is then fueled up and fired for approximately 50 seconds while lashed to the stand.

Upon successful completion of static firing, the rocket is completely assembled and for 10 days undergoes pre-flight tests similar to the ones conducted in the Baltimore test tower.

• **Preparing for launch**—Suddenly, the moment for launching approaches and the giant 7-story gantry surrounding the 22,500-lb. rocket swarms with activity. Three moveable platforms on the gantry are jammed with equipment. An elevator hums restlessly up and down inside while a crane atop the gantry switches equipment with a long steel arm to where it is needed.

The gantry, too, has a link with the *Viking* past of *Vanguard*. The same one which Layton constructed at White Sands was dismantled and reassembled at the Cape to fire *Vikings* 13 and 14 in the successful December, 1956, and May, 1957, TV-O and TV-I shots of *Vanguard* components. TV-I was a lift-off of the *Vanguard* third stage.

• **Shot into space**—On launch day, the countdown begins 6 hours and 40 minutes from time zero with the Minitrack transmitters switched "on" and the satellite operating.

Approximately six hours before launch, the rocket propane tanks are charged. The second-stage UDMH tank is serviced and white fuming nitric acid is pumped into the tank in the second stage. First-stage tanks are fueled with LOX and kerosene.

Helium and hydrogen peroxide are also put into their respective tanks in the first stage. The helium sphere in the second stage is filled.

If all the checks are good, the command to fire is given.

VERTICAL tower at Martin-Baltimore subjects *Vanguard* to complete dynamic tests to verify pre-design analysis. The 97 ft. high tower has five working levels spaced at instrumentation sections of the rocket.

Vacuum Jacketing Cuts Fuel Losses

CEC reports its jacketed lines reduces boil-off by half, compared to those insulated with other materials

PASADENA, CALIF.—A major source of boil-off loss in cryogenic fuel transfer systems for missiles can be minimized by jacketing the lines in high vacuum, according to engineers at the Rochester Division of Consolidated Electrodynamics Corp.

Six or more gallons of fuel often is lost for each gallon delivered to the missile with present transfer systems. According to CEC, vacuum-jacketed lines have reduced boil-off by 50%, compared with lines insulated with asbestos, glass and cork.

In the CEC lines, a small fuel-carrying pipe is installed inside a larger one. The area between the pipes is evacuated to a pressure of 1 x 10^{-5} mm of mercury, or lower. This reduces heat transfer by conduction and convection. The outer surface of the inner pipe is highly finished to reflect radiant heat.

Bayonet-type joints held to a 0.005-inch diameter tolerance are provided between pipe sections to produce positive leakproof connections. The flange in each female joint is designed to capture completely the O-ring inserted between sections. All mating surfaces are machined to a 63 micro-inch finish.

• Other types tested—Heat transfer with this insulation is as small as 3 BTU/ft/hr. Other types of insulation that have been tested at the National Bureau of Standards Cryogenics Engineering Laboratory at Boulder, Colo., had the following heat transfer values by comparison:

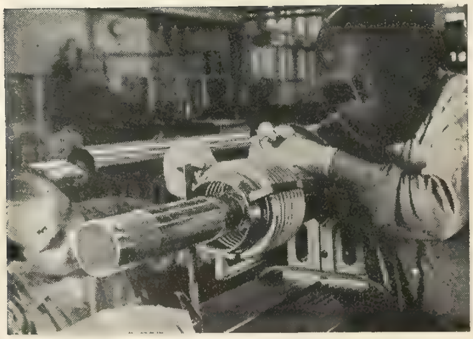
1. A reflective type composed of 13 concentric polished aluminum cylinders with spacers of light gauge stainless steel—186 BTU/ft/hr.
2. A rigid cellular 4¼-inch-thick glass insulation having a density of 10 pounds per cubic foot—72 BTU/ft/hr. (Heat transfer decreased only slightly for greater thickness of insulation.)
3. The same as 2., with insulation 2¼ inches thick—79 BTU/ft/hr.
4. Steam-blown glass fiber with a density of eight pounds per cubic foot —42 BTU/ft/hr.
5. Flame-blown glass fiber of three pounds per cubic foot density—40 BTU/ft/hr with 2-7/16-inch thickness and 22.9 BTU/ft/hr with 10-5/8-inch thickness.

• Chill-down required—One of the difficulties with conventional insulations is that the insulation itself requires a chill-down period during which large amounts of the liquid may boil away. In some cases, it was found that increasing the thickness of the insulation caused additional boil-off during the chill-down period. Condensation and resultant freezing within the insulation at times destroyed the insulation's thermal qualities.

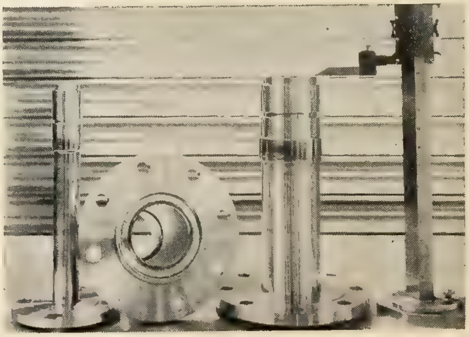
Uninsulated pipes, used initially to expedite the activation of missile test facilities, build up their own insulation in the form of snow coating. Boil-off is considerable during the chill-down period. If the ice buildup is rapid, excessive flaking results, exposing surfaces to added boil-off. Heat transfer losses from uninsulated lines are about double those of the reflective type shell, the least efficient of the insulating methods described above.

CEC also has developed modular vacuum-jacketed connections and bellows to permit expansion and contraction of the lines from heating and cooling. In addition, it permits a slight deviation from a straight line often necessary at missile-launching installations. These permit any configuration required at the launching or test site. Jacketed lines are produced in sections up to 40 feet in length and in various diameters.

To support and to permit optimum use of the vacuum transfer lines, CEC also is producing high-vacuum pumping systems, gauges, vacuum-jacketed valves, and leak detectors.



MODULAR connections and bellows permit expansion and contraction of lines.



JACKETED lines are produced in sections up to 40 ft. in length.

NOTABLE ACHIEVEMENTS AT JPL...

PIONEERING IN LIQUID PROPULSION SYSTEMS

From the first hypergolic system used as a jet-assisted takeoff for airplanes to the first tactical guided ballistic missile system, the Jet Propulsion Laboratory continues to be an active pioneer

Months before Pearl Harbor, JPL had tested America's first liquid rocket engines using spontaneously igniting propellants. By April 1942, a simple nitric acid-aniline propulsion system was designed into and successfully tested in an A-20-A Bomber for a jet-assisted takeoff. For high-altitude atmosphere research purposes, JPL then used the hypergolic liquid rocket system in the WAC CORPORAL. Placed as a second stage on a V-2 rocket, this became the BUMPER WAC rocket that established a World's altitude record of 242 miles in February 1949.

At the request of U.S. Army Ordnance, the Jet Propulsion Laboratory now began to develop a long-range guided ballistic missile system, incorporating the proven, smooth-burning light-weight acid-aniline system. These achievements sparked the development of a whole series of rocket vehicles. In 1954, the Army accepted the JPL developed CORPORAL, which became America's first tactical guided ballistic missile system; its accuracy exceeded design requirements.

Under the direction of the National Aeronautics and Space Administration, the experienced Jet Propulsion Laboratory research and development team is now working on storable, high-performance hypergolic liquid propulsion systems with which space vehicles may soon orbit the moon and planets.

CALIFORNIA INSTITUTE OF TECHNOLOGY
JET PROPULSION LABORATORY
A Research Facility of the National Aeronautics and Space Administration
PASADENA, CALIFORNIA

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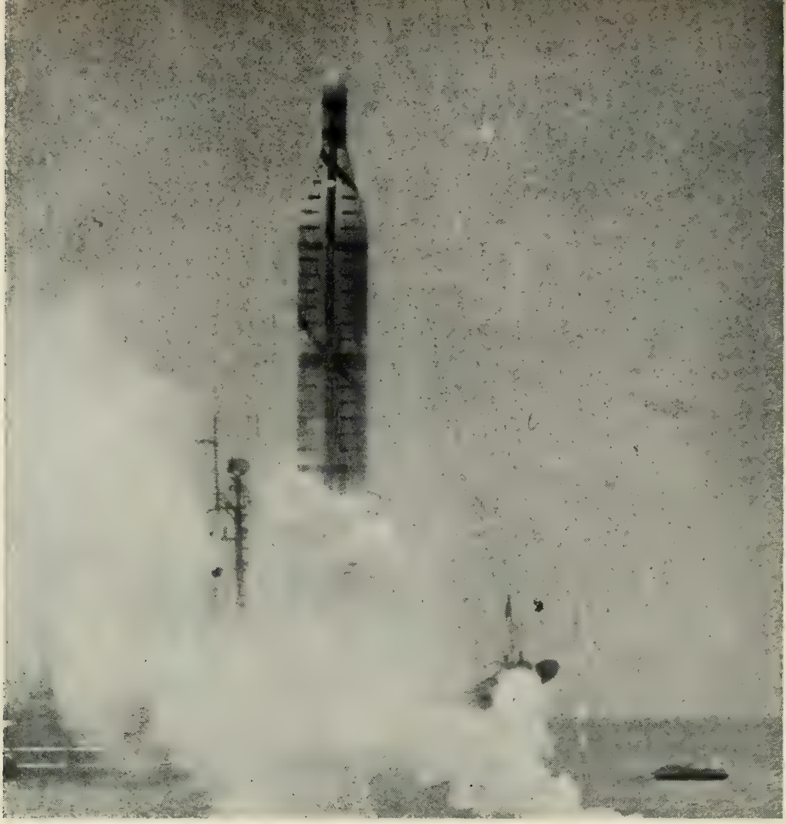
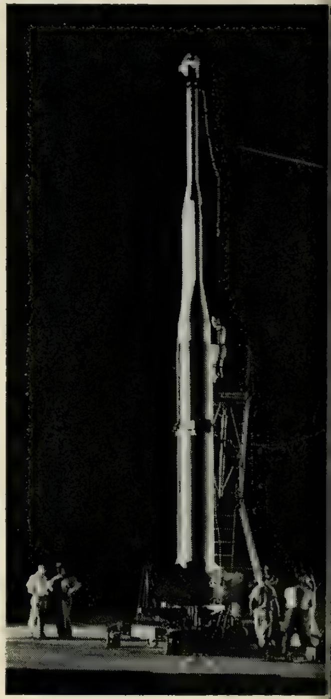


(left) Pop-up test of Navy Polaris IRBM.

(below) Nation's first successful re-entry tests were conducted with the Lockheed X-17.



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NASA Expands NACA Procurement Set-Up

Procurement chief says agency is decentralizing contracting and prefers doing business with established companies

BRACKETT

The National Aeronautics and Space Administration is the newest of the big government agencies. It is charged with development of the nation's civilian program. Ernest W. Brackett, recently appointed director of procurement and contracting, is responsible for getting NASA the tools it needs for the job. Brackett, a graduate of Cornell University, served as head of the procurement office of the Air Technical Service Command at Wright Field during World War II. After separation from service, he became civilian chief of the Air Force contract branch at the Pentagon. Later, he returned to Wright Field and served on the staff of the director of procurement and production. In his new post, Brackett is developing a procurement program for NASA. M/R obtained the following interview with him in an effort to answer some of industry's questions about the program.

by Erica M. Karr

Q. Will you explain the procurement set-up in NASA?

A. When Congress passed the law which set up NASA, it provided that it would take over the functions, facilities, and personnel of the National Advisory Committee for Aeronautics which had been in existence for many years. NACA had a good procurement organization. However, with the new organization set-up of NASA a much different type of contracting will be done.

For instance, NACA used to purchase test equipment, machine tools, and standard items for the work of the NACA laboratories. We will now be purchasing this and in addition will be making research and development contracts. Many of them are on a cost or cost-plus-fixed-fee basis, which is something NACA had not done.

NACA had three laboratories; one at Langley Field, Va., the Lewis Laboratory at Cleveland, Ohio, and the Ames Laboratory in Mountain View, Calif. Procurement in the past has been carried on at all three of these and they will continue to do so.

There is also procurement being done at High Speed Flight Station, Edwards Air Force Base, Calif. In addition, we are making contracts at Headquarters, NASA—most of these contracts being research and development. NASA also expects to build another laboratory in Beltsville, Md. When that is completed the contracting which is now done at NASA headquarters will be moved to Beltsville.

Q. Will NASA decentralize its procurement to local districts like the Ordnance or Navy?

A. Yes, NASA's plan is to decentralize procurement and eventually a very small part, if any, will be carried on through Washington headquarters. The Washington headquarters will be a staff function in procurement similar to the Pentagon staff principle.

At headquarters we will determine procurement policy, review and approve contracts and provide surveillance over the decentralized procurement offices. The plan is that NASA engineers and scientists also will be decentralized to the various laboratories and they will have certain projects assigned to them. The contracts to carry out those projects will be made by the laboratory which has charge of them.

For instance, the project to carry man into orbit, known as Project *Mercury,* is assigned to Langley Field. Our contract for the development of the space capsule with McDonnell Aircraft Co. was made at Langley.

Q. How does the contract procedure differ from that of ARPA or Defense Department?

A. ARPA does not make any contracts. It determines fields and projects where contracts should be made. These are assigned to the Army, Navy or Air Force which actually make the contracts. In NASA the technical people determine what projects should be covered by contract and they ask us to make contracts for them.

The NASA organization is divided into two sections. In one section are the technical people—engineers and scientists who determine requirements. The other is Business Administration. This includes budget, fiscal, personnel, and procurement and supply. Procurement does not determine any requirements. We only buy what the people who make the requirements determine they need.

Q. How long does it take NASA to make a contract?

A. We are attempting to effect our procurement without many of the details which larger organizations have. Where an organization is small, it is usually able to function faster because there are less formalities and less checks and balances, which are inherent in any large organization.

The space capsule contract with McDonnell was negotiated, written, and distributed within three weeks after selection of the contractor. We also have negotiated and placed in effect some contracts in less time than that.

Q. What is the system for review and approval of contracts in NASA?

A. There will be set up in procurement headquarters a committee to review all contracts over a certain amount made by any of the laboratories or at headquarters. Probably the minimum amount will be $100,000. It is quite possible that approval authority will be vested in the director of procurement and supply, although it may be that certain large contracts will be approved by Dr. T. Keith Glennan, the Administrator.

Q. What is NASA going to do for small business?

A. NASA plans on having an affirmative small business policy. I believe, not only because statute requires it, but for the benefit of NASA and American industry that small business should be assisted in every way possible. We already have made some substantial contracts in research and development with small business concerns. There are certain types of procurement, however, which only companies with a large amount of facilities and large staffs of engineers will be able to handle.

To date, we do not have a small business program in effect. We are waiting for a new man to report who is to take over this function and I think it only fair to wait until he has a chance to study the problem before we attempt to formulate a program.

Q. Is NASA's procurement running smoothly?

A. So far we have not run into any big obstacles. We do have a backlog of work. There are approximately 10 letters of intent which have been issued within the past few weeks and these we anticipate definitizing into contracts in the next few months. We have some new people reporting and we hope within 10 days to be in good shape.

Q. How can a firm obtain business from NASA?

A. NASA does not have to be sold something. They only buy what they need. My suggestion would be that any company interested in doing business with NASA obtain copies of Form 129, Bidder's Mailing List Application, a form we use for a business firm listing the items it has to sell and other information about its people and capacity.

A copy of this with any literature should be sent to one of the following: Sherwood L. Butler, Procurement Officer, Langley Research Center, Langley Field, Va.; E. C. Braig, Procurement Officer, Lewis Research Center, 21000 Brookpark Road, Cleveland 35, Ohio; Alvin S. Hertzog, Procurement Officer, Ames Research Center, Moffett Field, Calif.; M. E. Bowling, Procurement Officer, NASA High Speed Flight Station, Box 273, Edwards AFB, Calif.; and NASA Headquarters, 1520 H St., N.W., Washington, D.C. Any company interested in construction work should file a DD Form 1072, Construction Contractor Experience Data, which we will supply upon request.

The principal type of contract we now are making at headquarters is research and development. Companies that have a research and development set-up should tell us that fact. We take these forms when we receive them and place them in our source or bidder's list. When a project comes along, we take out our bidder's list and see what companies are interested in that type of procurement and they are invited to submit proposals if it is negotiated, or are sent invitations to bid if it is an advertised procurement. Companies may submit unsolicited proposals in the research and development field if they have an idea they think would be good for our type of work.

Q. What type of contracts and what forms will you be using?

A. We will purchase everything we can by formal advertising. This includes any standard commercial item or one which has a firm specification. We are now procuring liquid hydrogen for a four-year period by formal advertising. When it comes to research and development, we have nothing more than a performance specification and there are many details that have to be worked out by negotiation. Practically all these will be cost-plus-fixed-fee appropriations.

We are under the same statute for procurement as DOD—Public Law 413. The Department of Defense has as its implementing procedures the Armed Services Procurement Regulations and we have adopted these as our guide. Our standard contract clauses will be largely those found in the ASPR.

Q. What qualifications do you look for in a contractor?

A. We need contractors who are established in their particular line; those that have the necessary facilities and experienced people such as engineers. We would like to place our contracts with companies that have done work in the same field and have demonstrated their capability. Because of the crash program we have, we do not think it wise to place contracts with new and untried companies.

Q. Will you use some of the contractors who are making missiles and rockets?

A. Yes, we will be using some of those contractors. In fact, we will ask the military departments on some occasions to buy for us certain items they already are purchasing.

Q. Are you going to administer your own contracts and what will your system be?

A. Where one of the military departments has a contract administration set-up in a plant and we make a contract with that same contractor, we expect to ask that department to administer for us. This will avoid duplicating staffs and save the government money. For the most part, they will be administering our contracts just as they administer their own and this should make it easier for contractors. Otherwise, we will administer the contract ourselves.

Q. How do you determine what company should be selected as a contractor for a negotiated contract?

A. I think I can best illustrate this by telling you what we did with the space capsule contract. There were 30 companies which NASA considered interested in this procurement. These companies were invited to a conference, and the project was outlined to them.

We then sent a request for proposal to these companies and 13 submitted proposals. These were evaluated in two sections: (1) their technical sufficiency and (2) for the business side, which included such things as the fee and estimated cost. Before the evalution took place, a procedure was drawn up and points assigned to different phases of the proposal. Each proposal was then rated on a point basis by a board. The board reported the findings and recommendations to Dr. Glennan and his staff. As a result of this, McDonnell was selected. But some of the smaller contracts may not be treated in quite so much detail.

Q. What is the amount of the 1959 and 1960 budget for procurement?

A. The Fiscal 1959 budget for research and development is approximately $204,600,000. For construction and equipment, FY '59—$48,000,000 with a prospective supplemental budget of $24,200,000. The 1960 budget, if the funds are appropriated which have been requested, will be $331,100,000 for research and development and $57,800,000 for construction and equipment.

Q. How many contracts has NASA issued and what are the amounts?

A. We have issued 26 new contracts of over $25,000 which totaled approximately $126,103,000. In addition, we have outstanding 10 letters of intent. The amounts that those will total is not yet determined.

Q. Industry has been unhappy about NASA's restrictive patent provisions and has been clamoring for an arrangement like the one it has with the Defense Department. What is the status of this?

A. NASA will not attempt this year to have the provision changed. We want first to see how it works out in operation.

House Group Urges Reliability Program

Job is to recognize that reliability must be balanced against other factors

by Betty Oswald

WASHINGTON—How to improve the reliability of missiles, parts and components is still an important headache, the surveys and investigation staff of the House Appropriations Committee said in Part I of a report published as a part of Volume I of the Defense Department's Appropriations hearings for fiscal 1960. Part II of the report is classified.

The job—as the staff sees it—is to improve reliability while at the same time recognizing that it is only one of many performance factors which must be balanced against each other and against cost. To do this, the staff has recommended a major program as follows:

(1) Reliability requirements for missile parts, assemblies components and systems should be written into military specifications wherever practicable. In cases where specifications can't be written, the staff wants contracts to require suppliers to adopt and maintain definite programs of indoctrination, workmanship, review and inspection in support of reliability.

(2) Defense Department should arrange for cooperative centralized planning of tests to acquire an accumulate environmental data of maximum value to missile programs generally. The staff found that Office of Director of Guided Missiles had failed to take an active enough position in the reliability effort.

(3) Further development and use of simulators for simultaneous environmental testing and for simulated flight testing of parts, components and completed missiles.

(4) An active program is needed for the interchange of information among missile agencies and contractors on performance of components and parts and on capabilities of suppliers.

(5) A consistent set of terms, definitions and practices relating to reliability is needed. The report recommends that Defense Department set up a joint project to get the job done.

(6) Both Defense Department and the contractors should continue and enhance education and training in all aspects of reliability for all levels of personnel, including management.

(7) Army, Navy and Air Force should continue and expand research on the mathematical and statistical aspects of reliability and of the publication of suitable engineering handbooks.

(8) Defense Department should encourage and stimulate broad programs of basic and applied research, independently of specific missile programs. Emphasis should be on new principles and techniques, mechanisms of failure, and the properties of materials.

(9) Office of Secretary of Defense should arrange surveys of the relative effectiveness of the different approaches of Army, Navy and Air Force.

(10) OSD should take greater initiative in identifying and assessing common problems in reliability and in developing integrated programs for their solution.

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Industry Putting Increased Emphasis on HEF Processes

But the physical and metallurgical problems still remain largely unanswered with techniques being debated

by Frank G. McGuire

LOS ANGELES—The missile industry is giving increasing attention to the possibilities of high-energy forming (HEF) of metals—a process that can be expected to achieve tremendous growth.

But the problems involved in HEF are towering, too, according to experts at Lockheed, Convair, Aerojet-General, NOTS, Colorado School of Mines, Grumman, Ryan, Propellex Chemical Corp., Nitroform, Inc., Winchester-Western Div. of Olin-Mathieson and many other firms, government agencies and universities.

They are seeking answers to such questions as: "Should we or shouldn't we use explosives?" "What should we use as a transmitting medium—and how much of it?" "What are the physical and metallurgical factors involved?"

This last question involves a more lengthy answer, perhaps, than all other questions combined. Questions of stress, strain, radial displacement, deformation, dislocation, critical impact velocity, initial velocity, center deflection, and many other considerations, are still under hot debate.

The practical results to be expected from a given set of circumstances, however, are a little less controversial in nature. According to Dr. John S. Rinehart, director of the mining research laboratory at the Colorado School of Mines, "the thing that impresses me most about the high-energy forming process is that the results are so exactly reproducible, and capable of being scaled up or down to meet requirements."

• **Several approaches**—In actual use, there are several approaches to the problem of forming a piece of metal by the high-energy process. They involve: applying a sudden release of energy directly against a workpiece, forcing it to assume the configuration of a die; applying the energy to a transmitting medium, which in turn acts on the metal, forcing it to assume the shape of the die; or applying the energy to a piston, which works on a medium, which then acts upon the workpiece, forcing it to assume the shape of the die. Some consider the latter the most conservative approach.

During the 11th Western Metals Congress held here recently, the question of explosives arose during a technical session. In using explosives as a source of sudden energy, some experimenters had chosen dynamite, others had picked various commercial and military types.

R. A. Cooley, executive vice president of Propellex Chemical Corp., cited the possibility of using propellant powders for explosive forming, since they can attain burning rates as low as one foot per second. Joseph L. Bird, president of Nitroform, Inc., stated that his firm's experiments had shown both propellant powders and dynamite to be almost valueless. He said the company is now using RDX and primacord. Some firms cited initial trials with shotgun shells. To all of this, Aerojet's Dr. L. Zernow retorted: "Use the cheapest."

The power of various explosives has a definite bearing on the results to be obtained. TNT, for example, has a detonation wave with a velocity of 24,000 fps, and the gas bubble formed by the explosion has an initial pressure approaching 900,000 psi.

• **Rapid exploding**—Experts in the HEF process are still debating the merits of a rapid explosion, applying the maximum force to the workpiece over a minimum of time. C. O. Williams of Winchester suggests that "one of the greatest problems . . . is to prepare a charge which contains in sheet form a very slight amount of high explosive per surface unit but which will support continuous detonation. . . . We often hear that we should hit the workpiece with maximum force in a minimum amount of time in order to assure maximum elongation. Perhaps in many instances the opposite is true." Winchester has, in the past 18 months, produced 35,000 parts by the explosive forming method.

In explosive forming with high explosives, the initial impact of the shock wave accelerates the workpiece away from the wave, which keeps the metal moving through inertia until the workpiece fills the configuration of the die cavity. The time period from detonation to complete formation of the part is measured in milliseconds. The void between the workpiece and the surface of the die is vacated by means of a vacuum line operating through a porous metal section at the base of the die.

Lockheed Aircraft Corp., possessor of an AMC contract to explore the HEF process, says its work is purely experimental and that it is engaged in no production work. Glen N. Rardin, project engineer at Lockheed, said: "We are making hundreds of shots, just determining the basic curves of what each shot does. We've not yet proven whether the pressure bubble or the shock wave does the work." Dr. Zernow of Aerojet later commented that: "The pressure bubble can be virtually discounted." In the series of HEF experiments conducted by Aerojet, he noted, work had been done on metal plate up to two inches thick, as well as on armor plate.

The reproducibility of parts was emphasized by Ryan Aeronautical Co., which reported that a part formerly requiring an eight-hour setup time for tooling was now being produced after a fifteen-minute setup time and 1/3000th-second for actual forming. "Once we have the right backing, proper waterhead and proper charge and placing, we can get a run of parts just as identical as it is possible to make them," a Ryan spokesman said, adding that the firm expects to have 30 to 40 parts in production by the HEF process within a month. He also noted that a dimensional variation of less than 1/2000th inch is routine, and that cost of tooling is 1/10th the cost of conventional tooling.

• **Practical application**—In its very simplest form, the setup for explosive forming consists of a female die, a workpiece and an explosive charge. The charge can be either suspended over the workpiece, thus in effect using air as a transmitting medium; or, in sheet form, the explosive can be placed directly on the workpiece. (This latter variation is also being considered for the joining of dissimilar metals to produce composites.)

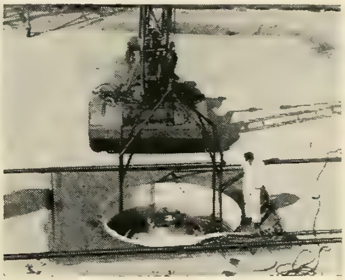
Using water as a transmitting medium, as pioneered by Convair-Fort Worth, the process takes place in a tank or pit. Male or female dies can be used and the water is kept from filling the die cavity by use of a seal between the die and workpiece. (Other transmitting media besides air and water are feasible, but their use has generally been considered unnecessary in view of the slight advantage to be gained, compared with costs of, for example, oil.)

Another of the numerous variations possible involves the use of a parabolic reflector in conjunction with a shaped charge. By this method, shock and pressure waves force the workpiece into the die. The exact deformation desired is dependent upon the accuracy in shaping the reflector and charge in order to direct the explosive force in direct proportion to the change wanted.

Hemispheres and cylindrical shapes are producible through use of a "free-forming" high explosive arrangement using no die. A blank is placed over an open die ring, above which is a hold-down cylinder having the same diameter as the die. In the cylinder is a polyethylene bag containing water and the charge. Tank ends up to 10 feet diameter are formed in this manner.

In still another method, a diaphragm such as rubber sheeting is placed over the workpiece, which is held in a platen press. Force from an explosive is transmitted to the liquid medium, thence to the diaphragm and thence to the workpiece.

BOEING AND RYAN are typical examples of companies engaging in research for HEF of metals. ***Bomarc*** **fuel tanks will be produced by this method.**



Small parts may be formed by the simple act of firing a blank cartridge into the cavity. This works especially well with small cylindrical sections requiring a bulge, or like deformation, to be worked into the shape. In this instance, a closed die is feasible. Systems involving hydraulic pistons avoid direct use of the expanding gases to act upon a tubular workpiece. In such an arrangement, a blank cartridge is fired, actuating a piston which forces hydraulic fluid into the tubular blank, causing the bulge into the die cavity. This method is also usable for blanking, shearing, cupping and forming.

• **Non-explosive forming**—The smaller portion of effort in the HEF field is devoted to other than explosive methods. Convair-San Diego, casting a "dissenting vote," cites the ability of hot expanding gases, hydraulic pressures, collapsing magnetic fields, and other sources of sudden energy to do substantially the same job as explosives.

J. B. Ottestad, Project Engineer of Convair's Dynapack project concerned with high-energy forming, termed the machining industry "archaic" in its concepts. He spoke of the Hyge machine developed at Convair for the forming of metals through high-energy rates. The machine uses no explosive charge and is composed of two chambers connected by an orifice capable of being closed off by the end of a piston. A small pressure in the lower section, chamber "A," presses the piston against the orifice, sealing it. When a gas under pressures up to 2000 psi is suddenly released into the upper section, chamber "B," the piston is driven with extreme rapidity against a transmitting medium which acts upon a workpiece, forcing it into a die.

The Hyge machine, Convair says, can be utilized for sheet-metal forming, forging, extruding, compacting of metal powders or ceramics, blanking and shearing and casting under high pressures.

In considering the "newness" of the entire approach of high energy forming of metals, C. O. Williams, of Winchester, noted that a British patent issued in 1897 just about covers every major method of forming by high-energy rates today. However, until the need for using high-strength alloys in present-day vehicles arose, there was no economic justification for using explosives. In recent years, however, "the missiles have re-focussed attention on explosive forming."

What's Coming in Materials Research?

A leader in the field says costly and less glamorous production research has been neglected but novel techniques are being developed for fabrication and screening of new materials

by Arthur R. Lytle*
Vice President and Director of Research
Union Carbide Metals Co.

NEW YORK—The popular concept of the future is a sky full of jet planes and missile-type objects. Fulfillment of this vision will require finding answers to a multitude of questions—some political, some economic, some social, but, at present, mostly technical.

One necessity will be an optimum combination of minimum gross weight with maximum payload. This will demand the use of materials in the most advantageous way—words that are easy to say but very difficult to implement.

With these thoughts in mind, what should be done about research of materials for future missiles, re-entry space vehicles, jet engines, etc.? This is a very difficult question to answer because in this field, more than in almost any other, objectives of research cannot be spelled out and trends in technology are not only not clear but may be appreciably distorted from our present viewpoint.

Nevertheless, let us take a broad look at our present position in respect to the more familiar materials.

- **Ultimate in alloys**—In the future, as in the past, we probably will have to place our main dependence on wrought and cast metals. To meet increasingly severe demands, metallurgical technology has been progressively advancing through the iron-base, stainless, titanium, nickel and cobalt-base alloys and is now rapidly entering the refractory, heavy metal area typified by columbium, chromium, molybdenum and tungsten.

As exemplified by bucket alloys for turbo-superchargers and jets, as well as vanes, performance of metals and major developments in design have progressively raised the limiting operating temperature of engines to about 1815°F. This, of course, is for long-time service, not short-life missiles. To reach this limit, it has been necessary to impose all known controls such as vacuum melting and casting, very close control of such strengthening agents as aluminum, titanium, zirconium, boron and also of the heat-treating process.

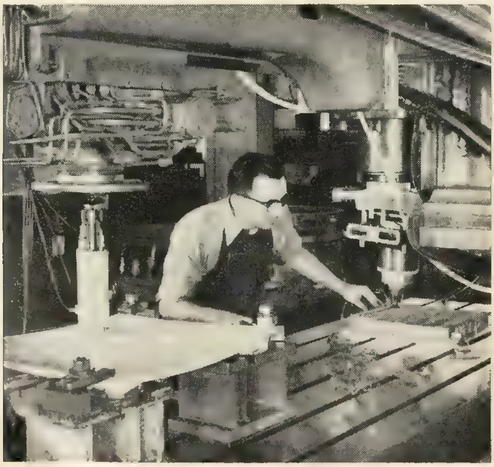
It is now generally agreed that not more than 100°F extra can be wrung from these alloys—and that only under the most rigorous conditions. Thus, barring a major, unexpected new development, the ultimate capabilities of these alloys have been attained.

- **Refractory metals**—For this reason, several years ago interest started focusing on the refractory metals and extensive studies have been underway in many laboratories. Despite imposing problems varying all the way from ore procurement to scrap recovery, some very significant improvements have already been made in performance of these metals and their alloys, thus bringing nearer their broader use.

The graph on page 33 shows the current optimum performance of various base metal systems at high temperature to their strength/weight ratios. In the cases of the higher-temperature metals and alloys, such as molybdenum, these are tests in vacuum or in inert atmosphere and hence represent idealized results which, it is hoped, the practical, oxidation-resistant or protected alloys yet to be developed may approach.

It does show clearly that in different, progressively higher-temperature ranges, each of these metals has excellent potential, justifying higher performance expectations. Simultaneous protection against excessive oxidation and development of high-temperature strength without detriment to fabrication capability, has not yet been accomplished; but current work is definitely promising to the extent that, for instance, columbium-base alloys usable at least for temperatures around 2000°F are expected within the next one to one and one-half years.

Typical target data for this general



MARTIN has developed a "Hula Head" device where the cutter head performs a hip movement as it machines complex honeycomb parts. Modified stylus with five pick-up points converts a 3-axis cutter to a 5-axis.

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*This paper, slightly condensed here, was prepared for presentation to the Society of Automotive Engineers National Aeronautic Meeting recently in New York City.

...NEWS IS HAPPENING AT NORTHROP

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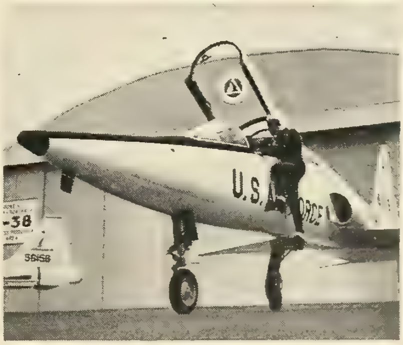


type service are 50,000 psi at 2550°F for 10 hours intermittent service. Fortunately, coatings hold good promise of protection up to at least 2500°F with a possibility of 3000°F useful performance, thus permitting utilization of the inherent strength of columbium- and molybdenum-based alloys.

Much of this work is being guided by new studies wherein determination is being made of the service life at temperatures near the melting point. In this work, the maximum load for one, two, and five minutes' life before fracture is determined, and new facts are coming to light on the relative effects of such phenomena as solid-solution hardening, persistence of cold work, etc. Such studies may make it possible to design metals and alloys especially for such ultra-short service, a possibility that does not hold now.

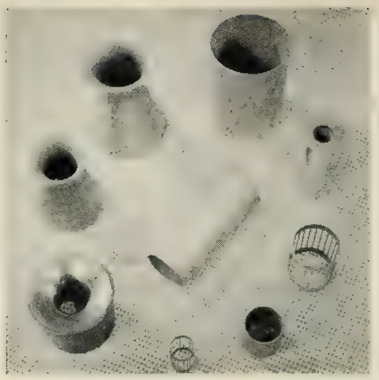
• **Production problem**—All the above work, so far, has been carried out in laboratories, some however on a moderate scale. General experience at the research laboratory level is that alloys can be produced on the test tube scale to meet very demanding services. The big problem that is almost always with us is the transfer and extrapolation of this experience for large-scale production of such metals of the quality and quantity needed for the expected usage.

Serious consideration is being given to setting up a sheet rolling program for refractory metals similar to that which has been underway on titanium alloys for the past two to three years. Such a program would be aimed at reproducing, on a commercial scale, findings of research studies on how to melt or sinter ingots, forge, extrude, roll or swage them to plate or bar, and preserve surface finish and mechanical properties—all within specified chemical and dimensional ranges.

A similar situation exists with many other materials. For instance, several special grades of graphite have been produced by research and development to meet certain rigid military requirements. However, before they can be made available in the sizes or quantities necessary for these needs, special equipment and facilities will have to be set up.

• **Production research neglected**—Although work in this area is not embraced in all definitions of research, it is an essential step and quite frequently requires the highest type of imaginative, resourceful thinking. It might be considered as production research, a much neglected area.

The unfortunate fact is that the tremendous importance of this phase of an overall program on most materials is less clearly recognized and much less glamorous than the creative phase. It is also the most costly portion of the program, involving larger quantities and frequently full-scale equipment.



SLIP-CASTING process has resulted in some novel tungsten parts.

IMPACT extrusions of columbium-base alloys permit normal fabrication.

Fortunately, this attitude has been changing in recent years and more effort and attention are now being placed on advanced research and development.

• **Non-metals handicapped**—Corresponding major advances have also been made in the non-metal materials—ceramics, plastics and graphites. Each of these has labored under very restrictive handicaps such as low strength, lack of toughness and low melting point, but these have been offset by the very desirable properties of high oxidation resistance, high-temperature stability, lightness, resistance to ablation, etc., so that the net result has been increased usage in such areas as jetavators, nozzles and leading edges.

• **Novel fabrication techniques**—Much attention has been given to the possibility of doing things in new ways—finding other ways whereby metal can be taken from, let us say, the ingot to the final product or even by-pass the ingot stage.

In some instances, such as powder metallurgy, this has been done primarily for economy purposes but, in the area in which we are now thinking, these moderately-novel fabrication techniques will be necessary in order to actually make an acceptable product at all. Most of the metals and structural materials with which we are going to be concerned in the future are not readily amenable to conventional fabricating techniques.

• **Slip-casting tungsten**—Tungsten can be produced in powder form to a very high degree of purity and has been fabricated into wire by well-known powder metallurgy techniques. Nevertheless, production of solid, fairly good-sized members of tungsten is quite difficult.

We have only recently learned how to melt even small ingots and many difficult problems can be envisioned in fabricating tungsten ingots. As an alternate, slip-casting has been developed for tungsten and currently experimental slip-castings of rocket nozzles and other complex parts weighing over 100 pounds are under test.

Earlier tests demonstrated the good performance of slip-cast metal ceramic nozzles, so it is known that the process is compatible with the desired high performance. Slip-casting techniques may be applicable to other metals and materials and could offer a very flexible, practical and easily-adapted production method for complex parts.

• **Gas-plating research**—There are other ways of putting metal into a desired form. Several methods of gas-plating, currently in the research stage, are extensions of, and appreciable improvements over, the older gas-plating methods. They show promise of producing built-up surfaces and possibly even stock for subsequent rolling and fabrication.

Nickel, cobalt and tungsten have been built up to reasonable thicknesses with densities of over 95%, sufficient for subsequent working. These processes have the merit again of forming complex shapes without the intervention of forging, rolling, etc.

A somewhat similar result can be attained with the new plasma arc torches, techniques again providing means for building up uniform, laminated or complex coatings or agglomerates either for subsequent processing or as final products.

All these processes are applicable to molybdenum, chromium, tungsten, and columbium alloys as well as to more prosaic conventional metals. The plasma torch has wider range, being useful also for very high-temperature non-metallic refractories as well as lower melting point materials.

It thus offers a tremendous research potential in producing novel constructional assemblies, by-passing the casting and fabricating difficulties of these metals or enabling the fabrication of desired complex structures to meet unusually severe service in local areas. The photographs on page 32 illustrate typical structures built up by this technique. In most of these, tungsten is the essential constituent.

• **New horizons**—Explosive forming and shock extrusion undoubtedly will open up entirely new eras. They have shown capabilities and advantages in the primary breakdown of some of the refractory metals.

Some metals, particularly tungsten, are malleable after the primary crystal structure has been broken down, and some of these extremely high-energy-rate upsetting and forming operations can bring about extreme plastic deformation in some metals when, under normal types of deformation, cracking and fracture would predominate.

• **Graphite for rockets**—The need for newer novel fabrication techniques in other fields is exemplified by the demands of the new generation of rockets. Graphite has the unusual capability of supporting load at temperatures on the order of over 5000°F and hence is destined to play a major role in these new designs.

However, increased resistance to oxidation and erosion is important for this service. Currently, appreciable gains have been obtained by impregnating graphite with silicon with subsequent conversion to a Si3N4-SiC complex, an extremely inert high-temperature material.

Other processes produce coatings of tungsten, tungsten alloys or titanium carbide. A variety of processes such as metallic cementation, gaseous diffusion, chemical replacement and high-temperature arc plating are applicable to this field, and some have already proven themselves.

The gain from this work, of course, is production of a composite material preserving the desirable high-temperature characteristics of graphite and protected by the serviceability performance of the coating materials.

• **Welding stability**—Under novel fabrication techniques, we must not neglect the problem of weldability. In the welding industry, this has always been with us, ever since moderately complex or stressed assemblies were welded, but the missile era introduces an entirely new degree of difficulty.

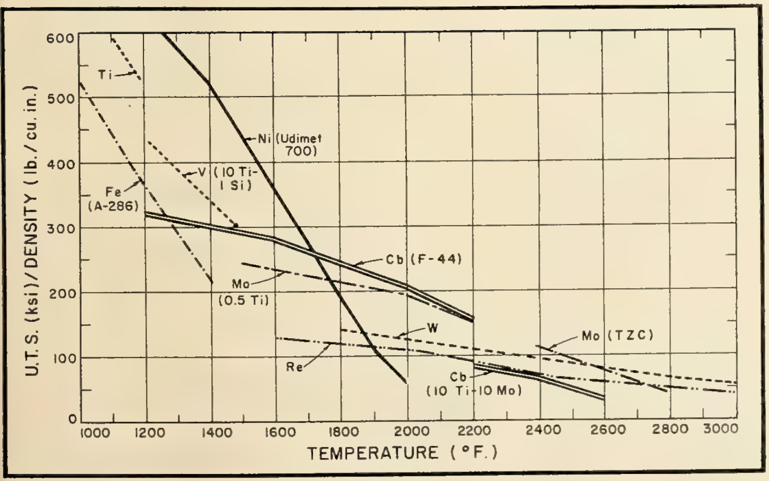
Actually, the problem is not in welding but in the stability of the welded structure in service.

These new problems arise from two major differences from normal practice, namely, use of newer metals and the premium on strength/weight ratio.

In the case of the new metals, the ability to be welded and preserve adequate mechanical properties is thus superimposed on the elementary problems of strength at temperature and of oxidation resistance. Real imaginative thinking will be necessary.

Similarly, the great emphasis on strength/weight ratio in structural metals, and the progressively increasing usage of sheet materials in missile design, are going to reintroduce on a large scale the problems of welding high hardenability steel or require the development of alternate methods of welding to circumvent the problem. To meet the desired yield strength/weight ratio of about 1,000,000, steels having yield strengths in the order of 250,000 to 300,000 psi are already being considered and, especially for solid fuel casings, metals having yield strengths of up to 400,000 psi are being sought.

In the past such steels have been considered, almost by definition, unweldable; but already, cold-worked stainless steels with yield strengths of 300,000 psi are being successfully fabricated in some forms by welding.



OPTIMUM performance of various base metal systems at high temperature.

The precise conditions attainable in electronically-controlled spot, seam and resistance welding lend great flexibility in choice of metals. The focused electron beam technique or one with similar characteristics may permit welding even the very hardenable die steels that are presently being considered.

• **Plasticity factor**—Of course, use of these steels with retention of full high-yield strength, sometimes approaching the ultimate strength, introduces lack of residual available plastic capability.

In many designs, especially where design stress approaches strength level of the material, allowance for unanticipated stressing is placed on yielding of the metal. If this has already been used during cold working, it may be unavailable for offsetting errors in design, so the designer will have to understand his stress conditions very completely or else design for the material.

• **Welding missile parts**—Besides being an essential aid to fabrication, welding under the proper conditions can be a major aid in production. One of the major problems in the missile business is the need for large members, but only a few of them. This is true of wide sheets, long extrusions, complex forgings, etc.

If suitable welding processes could be developed, applicable to the several metals, forms, etc., such large members could much more economically, and in much less time, be fabricated from smaller or shorted members.

Typical instances are the welding of short length of strip for making continuous strip and the welding of rails to mile-long continuous sections. These are desired products that could not be made in a plant of reasonable size.

So, when long extrusions are needed of new alloys, not amenable to normal extrusion processes or to normal ingot size, welding could play a very important part. Similar approaches could overcome the problem of wide sheets of difficult-to-form metals, producing them from harrower sheets of the desired tolerance and composition. Here considerable research may be needed in new or less widely used welding methods but the gains in money and time may be very appreciable.

• **New processing methods**—One of the objectives of present research is new processing methods to enhance the mechanical properties of materials.

In the metals field, one process of great interest is extremely high vacuum melting, promising remarkable improvements in purity, fabricability and ingot soundess. These methods, varying from electron beam melting to consumable arc melting at extreme low pressures, are already being broadly and intensively studied. There is, however, the counter-part of extremely high-pressure melting, an area which has only recently been investigated, but which shows considerable promise.

Presently, there are two objectives that should be gained by high-pressure melting. First, using high-pressure, it should be possible to suppress the volatilization of low melting point metals. Such high melting point metals as titanium, tungsten and columbium can be deoxidized or treated with low melting point or high vapor pressure metals such as magnesium, calcium, and lithium which are unsurpassed as deoxidizing agents. Under favorable conditions, even alloys of such metals might be preserved to normal ambient temperatures.

FIRST LARGE beryllium part ever forged successfully is on bed of 18,000-ton forging press at the Wyman-Gordon North Grafton, Mass., plant. Larger forging presses, including a 50,000-ton press, will be used to shape bigger and more complicated forms of beryllium in the future.

• **Freezing to alter crystals**—A second and possibly equally important hope for this type of metallurgy is that otherwise-unstable primary high-temperature phases may be stabilized or some fundamental rearrangement of the crystal structure may be induced during freezing to appreciably alter the properties of the metal.

As an example, it may be possible that the known body-center-cubic and, hence, ductile structure of beryllium which cannot be retained at room temperature otherwise, may be at least partially stabilized by pressure. However, no tests have been reported to demonstrate this.

The possibilities of this new type metallurgy in altering the mechanical and possibly high-temperature performance of the critical base alloys have been only preliminarily touched.

• **New materials**—The biggest hope for the future lies in the invention, creation or evolution of new materials possessing properties that are designed for specific needs. The materials picture at present is gradually developing into a recognizable over-all pattern and engineers are now trying to coordinate the demands of structures with the properties of materials.

Among the novel materials which are in relatively early stages of research but which may play a very important part in the future are such materials as inorganic polymers. Currently, this is a speculative project in its earliest stages because the mechanism whereby polymerization can develop or be forced in many inorganic systems is not now experienced or recognized.

However, polymerization has been achieved to a limited extent in some Si-O and metal-O-C linked systems; in other words, metal chelates and PN Cl_2 polymers are known. Undoubtedly, great advances still can be made in these and other systems.

By such polymerization it is hoped to gain, in materials that are not normally amenable to structural use, some semblance of the mechanical characteristics of organic plastics.

These materials, if satisfactory structurally, should develop stability at higher temperature and possibly, by combination, extend the temperature range of organic plastics in this whole general area. In their own right, they should possess basically different thermal, electrical and optical properties than their organic counterparts and hence should meet different needs.

• **Macro structure control**—The entire matter of composite structures, whether these are composed of plastics reinforced with metal fibers, ceramics stabilized by metal, or other supports, or metal powder compacts reinforced with other metal wire or mesh, is a fruitful field for future research, as herein is the effort to control macro rather than micro structure.

Such efforts are attempts to improve the strength/weight or strength/modulus ratios while preserving some inherent advantages of one of the constituents—for instance, the unusual thermal characteristics of plastics, i.e., their high heat capacity, low heat conductivity, and the character of their decomposition products, favor their use under extreme conditions of temperature and erosion.

However, their load-carrying capacity suffers appreciably. There are many problems to solve.

Are there better plastics than the phenolic-base type for ablative service? Can further advantage be gained from these materials by raising their modulus of elasticity, toughness and strength levels?

Glass fiber reinforcement has temperature limitations and asbestos has supplied added increments in performance, but other modes of strengthening seem applicable for further significant increments. How to introduce greater load-carrying capabilities into plastics may be a research project of considerable significance.

The same line of reasoning applies to the other composite-type structures. Of great assistance may be the effect of silicones in providing a high degree of bonding between plastic, metal, or inorganic material.

Apparently the Si-O bond is compatible with numerous other materials and is of tremendous value in improving the engineering utility of structures made from diverse materials. Solutions to these problems require coordinated plastic, metal and engineering skills, but the rewards from successful research should be great.

• **Graphite filaments**—A fairly recent development has been the announcement of graphite fibers and cloth. By processing synthetic organic filaments and cloth through novel graphitizing procedures, a textile material has been produced which is 99.9+% graphite, retains the relatively phenomenal tensile strength of 10-15,000 psi and is remarkably resistant to bending, folding, creasing, etc.

The significance of this is that it should now be possible to introduce

(Continued on page 49)

Advanced electro-mechanical systems

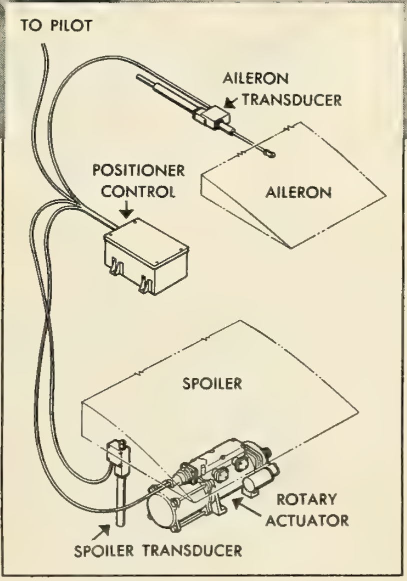
AiResearch Spoiler Servo Control System for Canadair's CL-28 and CL-44

A substantial increase in aileron effectiveness is achieved by the AiResearch Spoiler Servo Control System which augments the function of the aileron by increasing the rate of roll of the aircraft. Full spoiler surface travel is achieved in 0.5 seconds by electromagnetic clutching of the 4 H.P. power servo.

The added control surface of the Spoiler Control Servo System operates on the inboard side of each aileron. This AiResearch electro-mechanical system automatically synchronizes the spoiler control surface to move simultaneously with the aileron by utilizing a magnetic amplifier and position transducers in the closed loop servo system.

This new Spoiler Control System is but one of the many types of electro-mechanical systems developed and manufactured by AiResearch. Other recent examples include radar antenna positioning equipment, magnetron and Klystron tuning devices, and safe-arm mechanisms for missile igniting.

The company's more than 20 years of experience in the development and manufacture of electro-mechanical equipment extends into aircraft, ground handling, ordnance and missile systems of all types. AiResearch capability and system responsibility can meet your specific electro-mechanical requirements. Your inquiries are invited.



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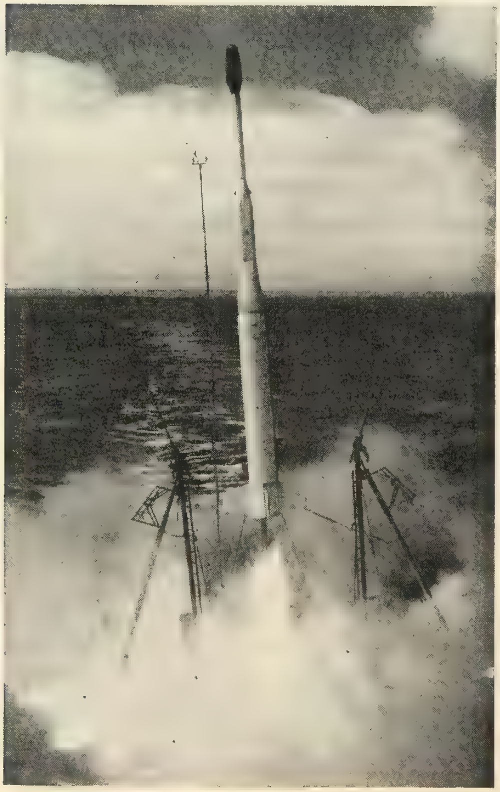
Nuclear Explosions in Space

Second of four articles by PROF. S. FRED SINGER

- ***Trapped radiation will be problem for manned vehicles***
- ***Close burst to ICBM could make its bomb inoperative***
- ***Defender may have to revise anti-ICBM strategies***



WASHINGTON—The obvious questions which are raised by atomic explosions in space have a practical military significance and are of great concern to engineers who are faced with the design of manned vehicles or missiles for travel above the atmosphere.

For example, at what distance from a burst will a satellite be vaporized or a man be incapacitated? Can an atomic explosion trigger off the nuclear warhead of a missile?

It has been generally believed that all of these effects were of no concern if the atomic burst is far enough away, either in space or in time.

But now, because of the *Argus* tests, this is no longer true. Because of the earth's magnetic field, another effect exists which lingers for hours or days after the actual explosion and which spreads all over the earth—trapped radiation forming an artificial radiation belt above the atmosphere. In this article we will try to assess this effect as well as the more direct effects in the immediate vicinity of the burst.

It may seem strange to the nonspecialist that such assessment is possible without recourse to classified data or even actual experiments. It turns out however, that order-of-magnitude calculations are in many cases sufficient to give a clearcut yes-or-no answer. In most practical cases, they show that an effect is either many times too large or many times too small.

Such order-of-magnitude calculations do not depend on the detailed design of atomic bombs or, for that matter, on any classified information. Yet, it is just such order-of-magnitude calculations which are of great importance to the space vehicle designer who is concerned with bomb effects.

• **Effects in a vacuum**—There are new and different phenomena involved in an atomic burst in space, in a near vacuum. In the absence of air the problem is much simpler; there is no shock wave, no blast effect, and thermal radiation is not very significant in relation to other radiations.

However, nuclear radiation from the fission of the uranium or plutonium is released and not attenuated by an atmosphere. The nuclear radiation intensity decreases only because of distance and varies as the inverse square of the distance.

Nuclear radiation is of course most dangerous to complicated molecules, and in particular to living cells. Thus, as has been remarked: "Man emerges as the most vulnerable component of a space weapon system." A dosage of 500 roentgens is considered lethal, while 20 to 50 roentgens will induce sickness. The usually accepted radiation tolerance limit is 150 milliroentgens per day which is about 10 times the average cosmic ray intensity above the atmosphere.

Instrumentation is relatively insensitive to nuclear radiation. Probably the most critical electronics item is a transistor. However even a p-n-p transistor will stand $6x10^6$ roentgens before its performance deteriorates appreciably.

Metals are particularly resistant, but if they do come too close to the nuclear burst the tremendous energy will simply vaporize them.

• **Effects of close bursts**—To assess accurately the effects of atomic explosions in space, it is first of all necessary to know the types of radiations, their energies and, of course, their intensities. It is not difficult to obtain this information using unclassified data on the physics of fission.

For this purpose we can cite some facts about fission by referencing "Nuclear Physics" by I. Kaplan. (Addison-Wesley, 1955)

A uranium nucleus which has absorbed a neutron will fission and break up into two smaller fragments. Most frequently the fragments are krypton of atomic weight 93 and barium 143. The velocity of the fragments is of the order of 10^8 cm/sec corresponding to a total kinetic energy of over 160 Mev (million electron volts).

In the fission also an average of 2.5 neutrons are released having a most probable energy of 0.8 Mev and a mean energy of 2 Mev; this multiplication of neutrons makes a chain reaction possible. A small fraction of neutrons, about 1%, are delayed and released after about 0.01 seconds; (this fact makes the operation of a controlled nuclear reactor possible). Prompt gamma rays are released having an energy of about 5 Mev.

• **Fragments interesting**—The two fission fragments are of particular interest. They are highly unstable and will undergo several radioactive decays before they reach a stable nucleus condition. In each decay they emit a negative beta particle, an electron. The energy of the beta rays can be calculated from nuclear theory and averages about 5 Mev. Since the fission fragments are far removed from nuclear stability, some beta ray energies can be very high, of the order of 10 Mev. These energies can also be calculated from nuclear theory.

Now let's take as our reference a fission bomb of 1 kiloton TNT (equivalent) yield. A simple calculation tells us that this release of energy corresponds to 4.2×10^{19} erg or 2.5×10^{25} Mev (this is a conventional energy unit in nuclear physics). If we make use of the fact that each fission releases about 200 Mev then we derive the total number of fissions as 1.3×10^{23}.

The weight of the fissioned atoms is only 0.1 pounds, but the amount of fissionable material in the bomb is of course much greater. For a small bomb, plutonium is a better material since each fission gives three neutrons. The critical (i.e., minimum) mass of a plutonium bomb has been estimated as about 10 pounds by T. Magnusson ("Construction and Operation of Atomic Weapons," *Kosmos,* Vol. 34, pp. 180-208, Stockholm, 1956.)

Knowing the number of fissions, we can calculate the output of neutrons, gamma rays, and beta rays (electrons). The latter are emitted with a wide range of energies, but it seems reasonable to assume about one high energy electron (about 2 Mev) per fission with the rest at much lower energies where their effects are of little importance.

• **RAND data**—It is well to mention that independent confirmation on the intensity of atomic bomb radiations in space comes from an unclassified report by the RAND Corporation to the House Space Committee. In this report the lethal range of a 20 kiloton bomb is given as 13 miles when exploded in free space.

A lethal dosage is 500 roentgens corresponding to an energy dissipation in one gram of tissue of 2.9×10^{10} Mev. Since high energy electrons lose about 1.5 Mev in traversing 1 cm of tissue, the fast electron flux from the bomb must be about 2×10^{10} electrons per cm^2 at a distance of 13 miles. Hence the total output of the bomb would be about 10^{24} electrons; this result is in close accord with our independent calculation.

Knowing the energy released in the bomb burst and knowing that the specific heat of most metals is of the order of 0.1 calories per gram per degree centigrade, we can easily calculate at what distance from a bomb explosion a satellite would be heated by, say, 100°C, or would perhaps be melted or vaporized. The energy flux from the explosion is simply spread out over a spherical surface so that at a distance of 100 yards the flux would be 4×10^{10} ergs per square centimeter, enough to vaporize one gram or a 0.15 inch thickness of aluminum.

To calculate the lethal range of an atomic burst in space, we can use the RAND formula which gives radiation dosage (in roentgens) $R = 4200P/d^2$ where P is the bomb's power in kilotons and d the distance in miles. For example, a 1 kiloton bomb will produce 500 roentgens at a distance of 3 miles. It should be remembered that this formula assumes no shielding, hence no absorption of the nuclear radiation.

• **Effects on nuclear warhead**—Not nearly so straightforward but very intriguing is the question whether a nuclear explosion can "set off" a nearby nuclear warhead. In principle, of course, it is not possible to induce a chain reaction in a nuclear warhead since the pieces of uranium which make up the bomb are separated so that they do not form a critical mass.

However, and this may be a very important point, the individual masses may be large enough to "amplify" each fission, i.e., a fission produced by an incoming neutron will set off many other fissions before it finally dies down. This amplification effect could lead to a great release of internal energy which may overheat and damage the bomb mechanism to make it inoperative. This appears to me to be the only way in which an atomic warhead can be affected.

To give an illustrative calculation, we may assume that at a distance of 0.3 mile from a 1 kiloton bomb explosion the neutron flux is 10^{13} per cm^2. If the amplification factor is taken to be 100 (it might be only 10 or it might be much greater, depending on the design of the bomb) and remembering that 200 Mev is released per fission, each incoming absorbed neutron will produce 1/30 erg of energy. Thus, energy releases of the

In the April 13 issue: Nuclear Explosions in Space and Their Direct Effect upon Radar and Long-Range Communications including ICBM Detection.

In the April 20 issue: Nuclear Explosions in Space and How They Can Be Detected by a Great Variety of Scientific Techniques.

order of 10^{12} ergs per cm^2 are quite possible and can lead to appreciable temperature changes, of the order of 200°, inside the bomb.

But again, we must remember that the nose cone itself may provide some shielding against nuclear radiation, except of course at very short distances from the burst.

• *Argus* tests—Perhaps of the greatest interest, especially in view of the *Argus* tests, are the long lasting effects of atomic bursts in space, caused by radiation trapped and retained in the earth's magnetic field. With the information on what is released, namely a 1 kiloton bomb exploded at 300 miles in the South Atlantic, together with a study of magnetic conditions in that area, one can make quite good estimates of the intensity of this trapped radiation.

Only the high energy electrons (beta rays) emitted from the fission fragments are of any significance for trapped radiation. The fission fragments themselves are unimportant, the gamma rays escape from the earth's field since they are uncharged, and most of the neutrons will escape. In any case, the decay of the low energy neutron only gives an electron of about 0.5 Mev which is not very effective.

We therefore have released in the explosion about 1.3×10^{23} high energy electrons. Of these, only a few percent remain trapped. A conservative estimate would be 1% after one hour. The rest are all dumped into the atmosphere. After about one hour, these electrons are somewhat diffused into a volume around the earth which is estimated to be 10^{26} cm^3. (This is a very conservative estimate and assumes that the line of force along which the particles are released sweeps up to a distance of two earth radii, i.e., it assumes that the release point was at a magnetic latitude of 45°.) The concentration of trapped electrons will then be 10^{-5} per cm^3 giving a flux of 3×10^5 per cm^2 per second or about 30 times greater than the maximum of the natural radiation belt. Hence, there should be no problem at all about detecting the presence of this trapped radiation from the *Argus* bursts.

• Lifetime—In order to assess the importance of the trapped electrons on manned or unmanned missiles and satellites, we must be able to calculate their lifetime.

This calculation of the length of time for which a particle remains trapped in the earth's magnetic field is an exceedingly difficult theoretical problem. The lifetime T depends on the nature, energy and trajectory of the particle, on the density of neutral atoms and of ions in the outer atmosphere, and on the degree of "noisiness" of the magnetic field which in turn is related to "activity" on the sun and therefore quite variable.

It may be preferable, as has been suggested by N. C. Christofilos and by the writer, to inject electrons artificially and measure the lifetime experimentally.

For 2 Mev electrons which do not travel too far from the plane of the magnetic equator we derive the approximate lifetimes. (See Table A)

(These values are substantially less for lower energy electrons and for particles whose trajectories extend far along the line of force into the denser atmosphere.)

Thus it is shown that the lifetime increases as we deal with radiation released at higher altitudes or higher latitudes, i.e., along a line of force which sweeps out to a greater altitude above the equator.

Basically, the reason is that the atmospheric density decreases so rapidly with altitude, and particles which remain in the equatorial plane will have a considerably longer lifetime than particles which dip down to lower altitudes. For particles trapped on lines of force which start at intermediate and high latitudes, the atmosphere probably is not the determining factor for lifetime. Instead, it is believed that the "noisiness" (i.e., wiggles) of the rather weak magnetic field causes scattering of the particles and eventually removes them from the trapped condition. This explains the absence of trapped particles near the poles.

In the case of occasional injections, as for example from atomic bombs, the lifetime gives the decay of the radiation with time. For continuous injection, however, the lifetime is very important since it determines the intensity. In fact, the concentration of particles is given roughly by the product of injection rate per unit volume and lifetime.

• Capabilities—Of course, as pointed out in the first article of this series, we can arrange to have nearly 100% of the particles trapped by proper adjustment of the release point. Furthermore, a larger bomb will release a correspondingly larger number of particles. One might therefore conceive of megaton bursts giving particle fluxes of the order of 3×10^{10} per cm^2 per second, which would be quite intense. In fact, such fluxes are near the theoretical limit of what can be trapped in the earth's magnetic field, which can store only a certain maximum concentration of particles. This is set by their reaction on the magnetic field itself. The particle energy density can be at most a fraction, say 10%, of the magnetic field energy density; or, expressed differently, the drift current of trapped particles cannot produce a magnetic field greater than about 10% of the earth's field B. Since the latter varies as the inverse cube of distance, the energy density which is $B^2/4\pi$ varies as $1/r^6$. (See Table B)

• Shielding problem—Without shielding such fluxes can be lethal in an exposure lasting only 1 second. Shielding against the trapped electrons is relatively easy, but care must be taken since about 1% of the electrons produce X-rays which penetrate deeper.

The effects of trapped electrons on nuclear warheads, however, seem hardly significant. The photofission process requires photons, and therefore electrons, of at least 5 Mev, and the efficiency of the process is very low in any case. A missile which spends only a few minutes above the atmosphere should survive even the maximum possible flux of trapped electrons.

TABLE A

Altitude (miles)	400	1000	2000	4000
Air Density (gm/cm^3)	4×10^{-16}	3×10^{-18}	10^{-18}	3×10^{-19}
Lifetime	3 hours	3 weeks	2 months	6 months

(Reference: Physical Review Letters, Vol. 1, pp. 171-173, 1958)

TABLE B

Distance from center of earth (measured in earth radii)	1.2	1.5	3.0	5.0
Max. particle concentration per cm^3 (assumed 1 Mev electrons)	83	22	1.34	1.6×10^{-2}
Max. particle flux per cm^2 per sec.	2.5×10^{12}	6.6×10^{11}	10^{10}	5×10^{8}

(Reference: Transactions American Geophysical Union, Vol. 38, pp. 190, 1951)

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Design of a radiation shield requires the following data: (Reference: "Radiation Shielding," Price, Horton and Spinney, Pergamon Press, 1957)

(1) types, energies and intensities of the radiations;

(2) rate of attenuation by shielding material; and

(3) acceptable level inside the shield

In close proximity to a bomb burst we deal with gamma-rays and neutrons at an energy level of one to a few Mev, and with low energy (less than 1 Mev) and high energy electrons.

For Gamma rays the absorption is roughly exponential but because of "build-up" it becomes more effective as the thickness of shield increases. Typical values for steel are:

Thickness of steel (inches)	1.4	2.6	3.5	4.2
Attenuation to	50%	20%	10%	5%

A fast neutron shield should contain (a) heavy elements to produce inelastic scattering (as well as attenuate gamma rays) (b) hydrogen to slow down neutrons to thermal energies, and (c) an absorber of thermal neutrons, perhaps lithium or boron, which does not itself emit a very penetrating gamma ray.

For energies less than a few Mev, electrons have a reasonably well defined maximum *range*. A rule of thumb gives the range (in gram/cm^2) as one-half the energy (in Mev). Thus a 2 Mev electron has a range of 1 gm/cm^2, or about 1/16 inch of aluminum.

• **Implication**—The implication of all this discussion to missile defense is quite apparent now. The trapped radiation appears to be a problem for manned missiles but no defense at all against nuclear warheads.

On the other hand, close exposures in the vicinity of a bomb burst can be serious, particularly for manned vehicles. And in the case of ICBM's carrying delicate atomic bombs, close bursts may make the bomb mechanism inoperative.

Of greater importance, however, than direct effects on incoming missiles may be the effect of atomic bursts on the atmosphere, and thereby on the detection of the missile. In other words, bomb effects appear to be favoring the aggressor rather than the defender and may require a careful study of anti-ICBM strategies.

New Details on Radiation

Coincidentally with the start of Prof. Singer's exclusive series of articles in M/R on "Nuclear Explosions in Space" last week, the National Aeronautics and Space Administration released details of the origin of the Van Allen radiation belts and their properties.

At a conference, some of the nation's top scientists disagreed upon many points, but essential agreement was reached on the following:

• The belts are made up of charged particles in trapped orbits which spiral about the lines of the earth's magnetic field in the manner of a helix, travelling back and forth from magnetic pole to magnetic pole.

• The particles in the outer belt are of solar origin, replenished periodically by streams of hot, energetic gases from the sun.

• Origin of the particles in the inner belt is unknown. The two major theories advanced were that they are (1) of solar origin, and fed into the inner belt from the outer belt by some as yet unexplained mechanism or internal motion, or (2) they are created by beta decay of cosmic rays.

• The lifetime of the particles ranges from many years out at 1000 kilometers to a few seconds at a few hundred kilometers.

• The protons have energies ranging from 400,000 volts to over 40 million volts, and the electrons from 20,000 volts to over 6 million volts.

• The particles can be grouped into two categories: hard and soft. The soft have low energies, while the hard have enough energy to penetrate a quarter-inch aluminum slab.

• There is a greater proportion of hard components to soft components in the inner belt than in the outer belt.

• U.S. and Russian space experiments show the soft components of the outer belt to be electrons. U.S. experiments indicate that the hard components are either electrons, protons, or both.

• There is a direct casual relationship between the heavy injection of high-energy solar gases into the outer belt and the aurora borealis and the aurora australis.

The above information was determined from the measurements made by *Explorers I, III,* and *IV,* and *Pioneers III* and *IV,* as well as information released by Soviet scientists from their experiments.

• **Belt locations**—The first of the two belts lies between 1000 and 3000 miles from the surface of the earth and the other between 8000 and 35,000. (These distances are at the points that the rockets penetrated the belts.)

The second belt's outer edge varies in distance from the earth, depending on whether it is in a state of quiescence or whether a large amount of solar gases is being injected into it.

This was indicated by information received from *Pioneer IV* that the outer belt extended some 9000 miles farther out from where it was when *Pioneer III* passed through it. *Pioneer IV* also encountered rapid fluctuations of radiation intensity even farther out.

• **Cause debated**—There was a split opinion as to what caused the inner belt. It is believed that it might be caused by the "entire gas content of this outer region" undergoing "a rather complicated internal motion which will assist it in taking a whole layer, a whole bundle at one level and allowing them . . . to appear at a different level."

On the other hand, Nicholas Christofilos of the University of California, father of the *Argus* experiment, agreed with Dr. S. Fred Singer that the inner belt was formed by beta decay of cosmic rays. Christofilos reasons that the high-energy particles of the inner belt have been established to be protons, that cosmic rays—not affected by the earth's magnetic force—penetrate the outer layer, and come in contact with the earth's atmosphere causing nuclear disintegration, and that neutrons bounce back into space where they disintegrate into protons and electrons, which are then captured by the earth's magnetic field.

One evidence Christofilos gives to support his theory is that the thin shell created by Project *Argus* had not moved more than 20 miles several weeks after the explosion, "which means if there are such convection currents (to move particles from the outer to inner layer) . . . this current to go from the outer to the inner belt will take an order of a year," which "appears unlikely since the inner belt lifetime is of that order or less."

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The Case for Components Research

The chief of Norden's Ketay Department warns of dangers in 'off the shelf' missile assembly; tells of company's drive to increase reliability

by Charles D. LaFond

WASHINGTON—The controversy may be long and only time will provide the answer, but proponents of the more-component-research philosophy are finding strong spokesmen.

Recently, Rear Adm. John T. Hayward, Assistant Chief of Naval Operations in charge of research, said that 60% of the Navy's research money should be spent for component development.

In Congress, it has been suggested that a research tithe by all prime contractors should be mandatory in future military procurement contracts. Presumably, a share of this 10% allocation would be spent in component research. How much depends on whose philosophy wins.

One of industry's most vigorous proponents of components—Bernard Levine, general manager of the Ketay Department of United Aircraft Corporation's Norden Division—also has long argued that too much emphasis is placed on development of whole missile systems.

During a recent M/R interview, Ketay's chief revealed what his department—one of the biggest names in the manufacture of precision electromechanical rotating control components and instruments—is doing and plans to do to perfect the building blocks of the missile system.

Q. **Based on current advancements in the missile industry as a whole and in the electronic-component field, in what area will the Norden Division, particularly the Ketay Department, direct its future production and research?**

A. The Norden Division will stress its activities primarily in inertial guidance and weapons systems. I represent a segment of the Norden Division which is a self-contained unit in the components business. We presently have a five-year forecast primarily in rotating components for data transmission and control. We feel that the great future lies in doing functions which have to be done, such as in integration, data transmission and so on. We are after increased reliability, greater accuracy, with smaller units. As you know, there are too many components now available and marketed that are very, very unreliable.

Q. **How much is being done by the government to develop better components?**

A. Well, they are buying some research, but we are currently investing our own money for about 30% of each research dollar at Ketay.

Q. **Your firm has done extensive work in developing small, highly stable gyros. Is there still a problem area here?**

A. One-inch gyros are now available, but there is a need for a lighter weight and cheaper missile. Too much of the missile is not power-planned. A lot of the components have to be ac-driven. But the gyro and the gyro pickoffs should be dc. Both should be battery-operated.

Q. **In your approach, you will continue to attempt to do more with less?**

A. Yes, we probably will have available early next year a completely floated gyro, in a one-inch frame which has an infinite resolution pickoff. We think this will be a great step forward for someone who wants to get a system up in the air rapidly with minimum of weight other than payload.

Q. **You spoke of Ketay's five-year forecast. Just what does this mean? Can you tell us some of the more important research areas in which you are now making advances?**

A. United Aircraft Corp. believes every phase of its operation should have a five-year program of the things it has to work on. This helps to give the corporation a position of technical excellence and helps to insure progress. I can go over some of our current and projected R&D work. These are in progress and will be finished this year.

We are working on an ultra-precision motor tachometer. The tachometers of today, that do integration, are accurate to 0.1% or 0.05%. We are aiming for an accuracy of 0.01% with a unit the size of a dime. The need for an electromagnetic integrator to promote the use of analog computers has long been a serious requirement and is generally acknowledged as the weakest link in the computer chain. The development of this device will re-establish the position of the rotation-components integrator in this field.

Also, we want to develop a boosterless resolver. We are investigating the procedures necessary to obtain a resolver capable of operating in a computing chain without benefit of isolation amplifiers—so that the phase shift of each resolver is approximately zero degrees and attenuation in the computer chain is minimized.

In conjunction with the use of booster amplifiers we are developing a resolver with an accuracy of 0.01%, which will minimize the error-causing effects of leakage inductance and magnetic heading displacements.

Q. **You mentioned the need for new components to meet missilery requirements for unusual environmental conditions. What are you doing to meet high-temperature or cosmic-radiation problems?**

A. Well, with heat we have a real problem—that is, when we take magnetic material above 500°C and through the Curie point. We have a 300°C synchro, but what we now want is a 600°C type. We are developing a synchro capable of operating in an ambient temperature range of from –55° to +500-600°C.

We have initiated a program for the development of nuclear-resistant components. Our problem here is to obtain satisfactory operation of our units in environments of integrated nuclear flux. I can't tell you any more about it now, but this is part of a long-range study.

Q. **You have indicated frequently in our discussion by implication and by your intensity when replying that all is not as it should be in component development. Just how do you feel about it?**

A. I go on a crusade about that. We all read in the newspaper where this airplane did so and so, and this missile did so and so. Every once in a while you will read where a missile didn't fire or a plane crashed. It is only then that people become aware of the fact that in this airplane, missile or whatever there are little components that make the thing work. It often only takes one component malfunction to make the system fail.

In other words, if a gyro stops functioning your missile suddenly goes awry. When one of the *Atlas* missiles was fired last summer, a news release indicated that it was the gyro that stopped spinning. What happened to the missile? It started shaking itself to pieces, and it just crumbled down to earth. The average person thinks about these things only in large glamorous chunks. They never stop to realize that it's all the little components that make up the bigger system.

If no one invented the self-starter, you might not like to drive your car. At best, only men would drive cars. It is this type of thing that we have dedicated ourselves to bring to the forefront in hopes of making better progress possible in automatic controls. This is something that is overlooked too often by the average person.

Q. It seems to me you can never reach a point of 100% reliability. There is always the element of human error. Why not concentrate in those areas where the chance of failure is the highest?

A. We are. You have to design reliability. I had a meeting with some of the military people at the Air Development Command, in Baltimore, after the first *Sputnik* went up. They were in an uproar because the Russians got there first. Yet they were the first to admit that the reason for our failure was that we had put tremendous emphasis on entire weapons systems, but had not taken the time to develop a better automatic control system or a better gyro.

In other words, a lot of people in the military assume that someone else will be developing a better product. They might be right or they might be wrong. The trouble is that we shouldn't let these things happen by chance.

Q. But in the beginning the task was to develop missiles in a hurry. It takes many firings of different kinds of missiles to produce enough data to know just what we need and where we have failed. Had we spent more time developing better components, we might still be waiting for our first operational missile complex. Don't you think that this component-research problem is now coming to the front because we employed the single

Energetic Champion of the Component Approach

by Erica M. Karr

Ketay's manager, 34-year-old Bernard Levine, is himself a good example of miniaturization. Packaged in a medium-sized frame, the characteristics that make up the man have combined to produce an "optimized" lead component in the Ketay operation. He is both a top-rung engineer and an able administrator with the ability to see the long-range picture along with the smallest detail.

He delegates authority willingly but doesn't let go of the rein completely, playing an active role in all final decisions.

The main basis of Levine's success, however, is his ability to get top performance out of his people. This is due partly to an instinctive ability to understand what makes them tick as individuals and to adjust his approach accordingly. Sensitive to their problems and aware of their capabilities, he draws from his men the extra effort that makes "best" out of "better" and "better" out of "good."

Levine credits part of this to his knowledge of psychology. But perhaps more important is an infectious enthusiasm. From a professorial-looking, modest introvert, the Levine personality Jeykllizes into vigorous, forcible fervor when a subject interests him.

Ketay's head man takes matter-of-factly his ascension to the top rung at a comparatively early age. He points out that his field is also a young one. But he explains that the direct cause was his conviction that the development and production of components could be profitable and had a tremendous future potential. "A system is no more reliable than the weakest of the components that make it up," he emphasizes.

Before Levine took over, according to a Pentagon engineering negotiator, Ketay was in the red. The company, which started as the Ketay Manufacturing Corp. in 1945, was merged into Norden-Ketay and finally evolved as the Ketay Department of United Aircraft's Norden Division with its purchase by UA last year. Today it is in the black. Its 800 employees at Commack, L. I., turn out an estimated $11-13 million gross business a year. Since its management by Levine, the Pentagon can count on deliveries on or ahead of schedule.

One reason for Ketay's pre-Levine difficulty was the imbalance of R&D work as related to production. The firm took on much of the Pentagon's special micro-lot "cat and dog" development work—six of these, and a half-dozen of those, mighty few with much in the way of production potential. Levine struck a balance and concentrated on development of high-production items.

Another Levine-generated plus was the production upswing which resulted from the spirit of competitiveness he awoke in the organization. Production lines with their weekly standings were posted prominently in the shop. Once a week while the laggards toiled, the winning line knocked off work to share a coffee and cake session with the boss. Although the reward was financially minor, jobs were tackled with a new vengeance while Levine found an ideal way to become more closely acquainted with his men.

Said one Navy contracting officer: "I've visited a lot of plants and I have yet to see Ketay's equal for cooperative spirit and general good will."

weapons concept and now have gone into a new phase?

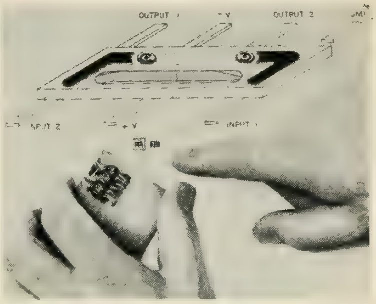
A. Yes, but too late. In this great problem of components, I think that when someone builds an individual weapon system for a plane or missile, they now find they need a hundred components offering high nuclear resistance and capable of operating in temperatures up to around 600°. No one in industry can really afford to invest his own money in finding out how to make them; the department building the system can't afford to pay for it out of its own budget.

So, basically it requires government-funded research, done separately, which is what Admiral Hayward, I believe, is pushing now. Some parts of the government have always pushed it, but it isn't as glamorous as flying missiles. It's very hard to go to Congress and convince the Congressmen that you should put $2 million into something that looks like a little motor.

In the last ten years, I would say, the major emphasis has been "get the weapons system out and use whatever components are available." So-called off-the-shelf items were employed and their hasn't been too much breakthrough in the last few years.

TI's Circuit Has 12 Components

NEW YORK—A major advance in ultramicroscopic semiconductor solid circuitry that promises to change many of the design concepts of computers and similar equipment has been introduced by Texas Instruments. A complete multivibrator circuit containing 12 electronic components has been formed integrally with a single piece of silicon or germanium less than 1/4 x 1/8 x 1/32 inch overall. It was demonstrated at the recent IRE show here.



Such circuits allow a fantastic possible component density of up to 34 million components per cubic foot. For comparison, the newly announced "micro-module" circuits are capable of densities somewhere in the order of 500 thousand per cubic foot while conventional printed circuit techniques provide a maximum density of a few thousand per foot.

According to TI President Pat Haggerty, the ultimate use of the ultramiscroscopic methods would allow the equivalent of all the computers in the United States to be contained in one unit the size of an average room.

The first circuit developed was a standard multivibrator with two diffused-base transistors, two capacitors, and eight resistors. An oscillator has also been designed which contains nine components.

The new solid circuits are expected to find greatest potential application where large numbers of repetitive circuits are required, such as in the computer field, and for missiles, rockets, satellites and all space vehicle instrumentation where weight, size, and extreme reliability are critical factors.

In announcing the new semiconductor circuits, Texas Instruments stressed that commercial models are not yet available in either sample or production quantities, although they are expected to be ready some time this year.

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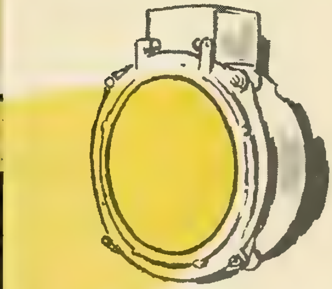

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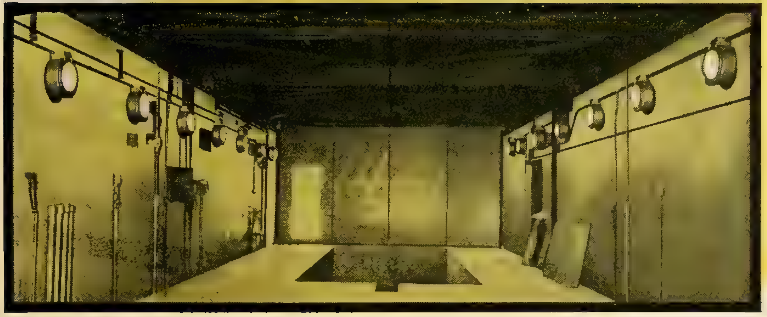

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propulsion engineering

Aerojet's Dan Kimball is not sure a nuclear rocket is practical. He says this is the consensus of many propulsion scientists, and asks Congress to authorize $50 million to be spent over several years to find out if nuclear propulsion is practical. Kimball told the House Committee on Science and Astronautics that very little has been done in the field so far. He also ventured that the U.S. is ahead of the Russians in solid propellants, about even in liquids—a statement based on Central Intelligence Agency reports to Aerojet.

The Committee wants to be sure CIA and other agencies are passing information along to industrial concerns that can use it. However, says Kimball: "We learn nothing new from the USSR."

Nuclear fuels get more research attention by NASA than recent reports indicate. A NASA staffer says the organization's effort in nuclear propulsion is "almost as great as the effort in chemicals, it's just that we can't talk very much about nuclear work." Publicity is scarce for two reasons: (1) Some of the work is justifiably classified for military reasons and, (2) NASA has to clear publicity on nuclear work with so many other people that it's sometimes not worth the effort.

The Air Force thinks scandium's melting point is 2822° F., instead of the 2192° F. that now appears in the literature. That explains the $60,000 contract to Union Carbide Metals to produce and study one pound of the very lightweight metal. Difficulty of production and high cost could be overruled by the phenomonally high melting point, if the AF is right.

The new storage tank insulating powder that's 26 times more effective than a vacuum is a major factor in almost all of Linde Company's recent bids on liquid gas storage tanks and production facilities. The closely-guarded material and Linde's commercialization of the ortho-hydrogen to para-hydrogen process (Propulsion Engineering, March 30) makes liquid H_2 as easy for Linde to handle as LOX is for many producers. Present vented liquid hydrogen tanks have a tremendously high loss rate—measured as a high rate/day—but the new powder makes possible unvented H_2 tanks with a loss rate of only 0.9%*/year.* No cold liquid nitrogen shield is required.

Until patents are in the clear, Linde will not even hint at the powder's composition. It's known, however, that it grew out of work on the earlier CS-5, SI-4, and SI-12 powders. The material is so good that Linde is even trying to talk Air Force BMD out of its plans to build LOX plants at most missile sites. Linde was asked to bid, but offered to build loss-proof storage tanks instead. Negotiations are up in the air, a Linde official says, because "there are some good arguments on both sides."

If the armed forces want oxygen fluoride, Pennsalt Chemicals will make it for them. But nobody will make this near-perfect oxidizer for carbon-based fuels until a market is guaranteed. Pennsalt says the lab technique of reacting fluorine with water won't do as a commercial process. A cheaper, easier to handle route to OF_2 would have to be found.

Although Pennsalt won't say whether its labs are going ahead with research even without a requirement from the military, the requirement probably will come. The reason: Although flourine is the oxidizer to use with H_2 for maximum I_{sp}, its combustion product with carbon is high molecular weight carbon tetrafluoride; low molecular weight carbon monoxide comes from combustion of carbon with oxygen rather than fluorine; thus, OF_2 is the ideal oxidizer for hydrocarbons, and it's easier to liquefy than oxygen or fluorine alone.

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by Fred S. Hunter

Questions have arisen, from time to time, regarding the structure design of the *Atlas* ICBM. Convair broke new ground in this area by developing a structure with a skin so thin that the interior has to be pressurized to preserve the shape of the body as propellants are consumed in flight, or when the missile is being transported on the ground. Structure weight was minimized. Mass ratio was improved.

But, said detractors, the structure was too fragile—"You could dent it with a hammer." So, recently, when the Scientific Advisory Board, engaged in a re-evaluation of all missile programs, arrived at Convair-Astronautics to take a reading on the *Atlas,* they found that Convair had thoughtfully placed a number of hammers within easy reach of a finished missile. "Go ahead, hit it," invited Convair. The SAB members swung lustily. Not a dent was registered.

The Air Force has engaged in a tremendous airlift to England with the *Thor* IRBM, transporting thousands of pounds of missiles and ground equipment in C-124 and C-133 aircraft. It also takes the *Titan* ICBM from Denver to the Missile Test Center at Cape Canaveral by C-133. But the *Atlas* still makes the trip from San Diego to Florida by truck, a nine-day journey entailing a total cost of $14,000. This is because the *Atlas,* a couple of feet greater in diameter than the *Titan,* is too tight a fit for the C-133's currently in operation.

But an updated C-133B model of the big Douglas turboprop transport will become available in 1960, and it incorporates enlarged, rear-loading doors, which are being installed specifically to simplify the loading of *Atlas.* With the C-133B, Douglas estimates the total cost of shipping an *Atlas* from San Diego to Canaveral by air at $9,200—a saving of nearly $5,000 as compared to surface transportation. Flight time will be seven hours, compared to nine days by truck. The $9,200 total includes indirect as well as direct operating costs, and also covers the return flight (with transporter) of the C-133B to San Diego. If cargo is carried on the return flight, the missile-delivery costs will be even less.

Most of the Douglas Aircraft Co.'s missile effort—*Thor, Genie, Honest John,* the *Nikes*—has centered in the Santa Monica Division, noted over the years as the home of the company's famed transport aircraft. But now we have the traditionally Navy division at El Segundo making important motions on the missile front. Four missile design sections have been added to El Segundo engineering, and a missiles project engineering office established. Previously, El Segundo has done some work on missile components for the Santa Monica Division, but now it will also come up with some design proposals of its own.

Pacific Missile Range expenditures during 1959 will total approximately $91 million, Rear Adm. Jack Monroe, PMR commander discloses. Construction of facilities, such as the new satellite launching pads in the Navy's Point Arguello area, will add up to $36 million; payrolls $25 million; equipment $16 million; aircraft and maintenance $11 million, and other expenses $3 million. Range management personnel has been built up during 13 years of operations at Point Mugu, and currently totals 5,000, divided about equally between military and civilian.

One of the countdowns on the *Discoverer I* at Vandenberg AFB was stopped at 15 seconds before launch, thus proving that the basic *Thor* system can be controlled when required, and also dispelling the fear—expressed by some British factions—that once the 9-to-12-minute terminal countdown is started, it might not be possible to halt operations.

RCA Demonstrates Thimble-Size Tubes

WASHINGTON—In a recent demonstration before representatives of the electronics industry, military, and press, RCA introduced prototypes of its thimble-size electron tubes.

Called "Nuvistors," the tiny tubes are capable of operation in temperatures from –320°F to +350°F. Since they are larger and require high power, the Nuvistors are not expected or intended to replace resistors. But for higher frequencies or for high-temperature operation the new tubes are said to be superior to transistors.

"Development of the new design represents a major breakthrough in tube size, pfierformance, power drain, an dreliability," said D. Y. Smith, vice-president and general manager, RCA Electron Tube Division. "It opens the way to mass production of high-erformance, thimble-size tubes having improved ruggedness, reliability and efficiency.

The new tubes are expected to lead important developments in such instruments as television sets, communications receivers, and computers. The tubes will contribute to building more compact and efficient electronic equipment for defense and industry, Smith added.

RCA will furnish developmental samples to the electronics industry within the next several months, Smith said. A small-signal triode and a small-signal tetrode will be offered first, and these will be followed at a later date by a beam power tube. According to present plans, RCA expects to start limited commercial production of the tubes in 1960 and mass production will follow later in the year. Prices then are expected to be competitive with other tubes and transistors.

The high-efficiency triodes and tetrodes are expected to find wide use in the logic and computing circuits of electronic computers. The power tetrode, capable of high peak current at low plate voltage, offers advantages for memory-core-driver applications. The beam power tube could be utilized in series voltage regulators, low-power transmitters, servo amplifiers, and high-power sound systems.

Preliminary tests indicate that Nuvistor tubes should meet the very critical military reliability and environmental objectives better than larger, traditional-design tubes. The materials used will maintain the excellent resistance of the electron tube to damage from nuclear radiation, Smith said.

. . . METALS

(Continued from page 34)

graphite as a high-temperature strengthening reinforcement or as a filament to achieve increased electrical and thermal conductivity while improving strength and minimizing failure due to shock loading.

The characteristics of such laminates made with suitable binders are striking. A laminated bar fully processed to over 99.5% graphite permits appreciable bending without fracture, a very unexpected performance of graphite.

• **Screening missile materials**—Simultaneously with the problem of creating new products, the designer and materials man is confronted with the continuing need for screening of potential or suggested materials.

Because of the extremely rigorous and critical conditions involved in such testing, practically the only dependable method is to test in actual missile structures or in very costly models under closely simulated service conditions.

Extremely expensive and time-consuming, this seriously restricts the number of materials or assemblies which can be tested. Some materials, of purely speculative value, may not be tested and some entire classes of materials may not be explored.

There is, therefore, a critical need for screening devices which could in a relatively short time test materials under simulated conditions and select those that have high promise. There have been developed recently the so-called arc plasma torches, at least one variation of which seems to be fully capable of being developed as a moderately flexible screening test for missile materials.

These torches can develop temperatures on the order of 15,000°F and gas velocities up to Mach 1-2, are large enough to enable testing of reasonable size assemblies, and can maintain such conditions for reasonable periods, measured in minutes. As they are still in early stages of development, there is considerable optimism that higher gas velocities will be attainable, thereby closely approaching the extreme service conditions that must be withstood.

The test has the added advantage that not only can the character of the atmosphere be changed within a fairly broad range, but erosion and corrosion phenomena can be studied by introducing compounds and solids into the flame which duplicate those produced by solid or liquid fuel propellants.

• **Filamentary crystals**—As an example of the need for initiating and continuing research in the new and advanced areas of materials in order to develop an untrammeled perspective, we might cite the example provided by filamentary crystals or "whiskers."

For seven years their astonishing strengths have been recognized and they have been characterized as representing nearly perfect crystallization—being generally free from dislocations, the lattice defects responsible for the relatively limited strength of many conventional crystalline materials.

Presumably because of this, they possess almost theoretical strength, in the order of 1,900,000 psi for iron, which is about 100 times the strength of ordinary crystals of iron, for instance.

Such materials behave elastically up to their maximum strength. So, in appropriate applications, they presumably would be useful to much higher than normal stress. Perforce the high elastic limits available in this sort of material is obtained with the exclusion of the usual plastic properties. This may inhibit the utilization of the high elastic strengths in many applications.

• **Unconventional methods**—It is of considerable interest that in some basic solid state studies of graphite, methods have also been evolved for the production of graphite filamentary crystals. These have indicated tensile strengths on the order of 3,000,000 psi, a 1000 to 1 increase over properties of normal graphite.

In the intense desire of design engineers to employ materials having maximum strength/weight ratio, these findings on perfect crystals of metals and other materials have occasionally suggested the possibility that larger, massive structures could be processed to have these characteristics.

However, it is now generally recognized that bulk material having the properties of whiskers will be produced only by unconventional methods yet to be developed. Some entirely new concepts have evolved recently based on work which has shown that in some cases the crystal structure of such strong whiskers in not as perfect as had previously been thought. This work, however, collaterally has indicated that some imperfect crystals have the unusual properties, while others do not—hence, less obvious factors may play a part in the phenomenon of high strength.

In spite of this uncertainty, the possibility that nearly theoretical strengths may be developed in bulk materials containing dislocations is encouraging.

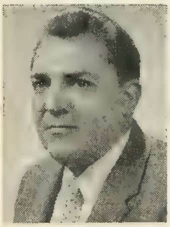
The total research effort in this general field is increasing in intensity and breadth as it portends fuller explanations of the basic problems of materials behavior.

people

Edmond C. (Collins) Buckley, former chief of the Instrument Research Division of the Langley Research Center, has been appointed Assistant Director for Space Flight Operations at National Aeronautics and Space Administration Headquarters, Washington, D.C. Buckley joined the National Advisory Committee for Aeronautics, predecessor of NASA, in 1930. Reporting to the Director of Space Flight Development, Buckley is responsible for planning and directing use of support systems for space research activities, including global tracking stations, data acquisition systems and networks, ground communications networks, and launch site facilities.

Jack Gray has been promoted to Senior Contract Administrator for Temco Aircraft Corp. Gray, formerly Contract Administrator, replaces **Howard Clark,** who was named Business Manager on the *Corvus* missile program. Gray will be in charge of administration of all subcontracts held by Temco.

In a recent appointment, **Charles Nater** became chief engineer of the Instrument Div. of Beckman & Whitley, Inc., San Carlos, Calif., manufacturers of high-speed cameras, meteorological instruments, and missile components. His earlier career was mainly with Canadian Westinghouse Co. of Hamilton, Ontario. Prior to this he was production superintendent at Holman Vulcan Ltd. and chief engineer of the industrial development department of the Ministry of Economy of the Republic of Guatemala.



NATER

Philip LeBoutillier, Jr. takes over as Deputy Assistant Secretary of Defense (Supply and Logistics), succeeding **Cecil P. Milne,** who has been nominated by the President to the Assistant Secretary of the Navy (Materiel). Milne, formerly vice president and general manager of Massey-Harris-Ferguson, Inc., has served as Deputy Assistant Secretary of Defense since November, 1957. LeBoutillier will assist the Assistant Secretary of Defense for Supply and Logistics, **Perkins McGuire,** who is responsible for the areas of transportation, supply, communications, petroleum, procurement, production, planning and requirements, and small business.

NAVY

$101,701,000—Grumman Aircraft Engineering Corp., for development and production of the A2F-1 carrier-based jet attack plane, to be armed with *Eagle* missiles.

$13,500,000—Philco Corp., for continued production of *Sidewinder* guided missiles.

$6,000,000—General Electric Co., for continued production of *Sidewinder* guided missiles.

$391,000—Beckman Instruments, Inc., for electronic data handling systems for *Talos* automatic check-out equipment.

ARMY

$12,870,000—Malan Construction Corp., New York City, for construction of ICBM sites at Offutt AFB, Neb.

$12,083,720—California Institute of Technology, for *Sergeant* research program and wind tunnel.

$10,911,000—The Firestone Tire & Rubber Co., for guided missile system.

$9,950,000—Western Electric Co., Inc., for planning on *Nike-Zeus* program.

$8,900,000—Western Electric Co., Inc., for *Nike-Hercules* ground and test equipment (two contracts).

$3,116,264—Raytheon Manufacturing Co., for the *Hawk* program.

$2,745,000—Rocketdyne Div., North American Aviation, Inc., for classified work.

$1,589,029—Brown Engineering Co., Huntsville, Ala., for engineering services.

$1,098,768—Intercontinental Manufacturing Co., Inc., Garland, Tex., subsidiary of U.S. Hoffman Machinery Corp., for XM-30 Jato (*Hercules*) solid sustainer motor metal parts.

$914,830—Phelps Construction Co. and H. Clinton Rodgers, El Paso, Tex. (joint venture), for up-range service area development at White Sands Missile Range.

$747,737—Rheem Manufacturing Co., Downey, Calif., for classified (Zebra) work.

$670,695—Macco Corp., H. C. Smith Construction Co. and Kemper Construction Co., Paramount, Calif. (joint venture), for silo launch test complex, phase I at Edwards AFB.

$450,000—The Budd Co., Philadelphia, for ground transportation units for the *Redstone* (subcontract from Chrysler).

$394,074—Telemeter Magnetics, Inc., Los Angeles, for a high-speed digital memory system.

$330,345—Bovee Inc., Paramount, Calif., for LOX generator facility at Vandenberg AFB.

$246,242—Douglas Aircraft Co., Inc., for *Nike* launching area items. (**Ryan Aeronautical Co.** received a subcontract from Firestone for liquid fuel rocket motors for *Corporal* missiles. Amount was not disclosed.)

AIR FORCE

$3,817,183—Motorola Inc., Military Electronics Div., for 168 radar guidance beacons and command data links for *Bomarc.*

$2,612,343—Pan American World Airways, Inc., for increase in funds (awarded by Patrick AFB).

$2,400,000—The Martin Co., for expansion of the *Mace* program.

$999,019—Hewlett-Packard Co., Palo Alto, Calif., for various electronic items.

$493,870—Sperry-Rand Corp., Sperry Electronic Tube Div., for electron tubes.

$437,000—Sylvania Electric Products, Inc., for electron tubes.

$387,120—General Electric Co., Missile and Space Vehicles Dept., for R&D of a converter to permit conversion of thermal energy to electrical power.

$332,896—Sperry-Rand Corp., Sperry Gyroscope Co., for radar set components, spare parts and data for Navy aircraft and Project *Black Knight.*

$268,470—General Electric Co., Scranton, Pa., for electron tubes.

$264,345—The Hickok Electrical Instrument Co., Cleveland, for electron tube test sets and handbooks.

$248,800—Grand Central Rocket Co., for Viper 1-B rocket engines and igniters.

$242,700—Eitel-McCullough, Inc., San Carlos, Calif., for electron tubes (two contracts).

$223,720—Tung-Sol Electric Inc., Newark, N.J., for electron tubes.

About the Cover

Pictured on the cover this week is the *X-15* cradled under the wing of the mother B-52 during their maiden flight together March 10.

The *X-15* made its second captive flight April 1. It was again carried to 38,000 feet for aerodynamic checks and for crew familiarization of the two-hour inflight check-out.

Scott Crossfield, North American test pilot, remained in the *X-15's* cockpit for the entire flight. AF-NASA programming calls for another static test before the rocket plane is released for its first glide test.

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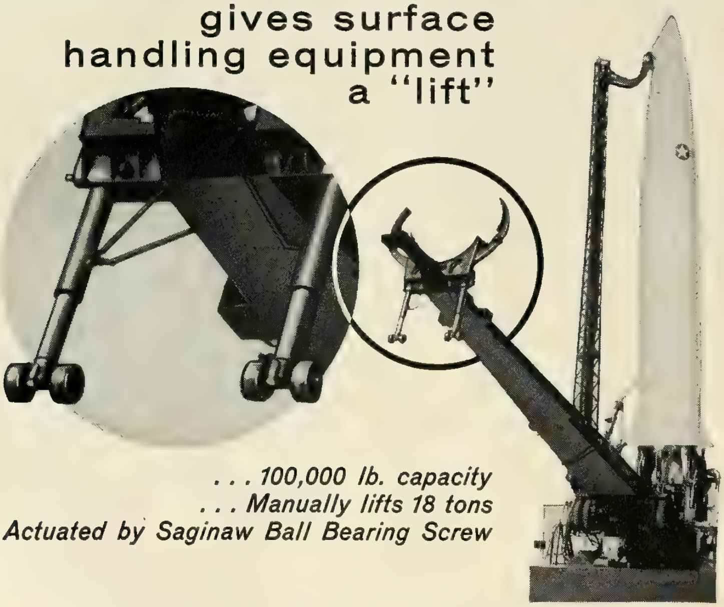

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APRIL

Fifth National Military-Industrial Conference, Palmer House, Chicago, Apr. 6-8.

American Welding Society, 1959 Welding Show and 40th Annual Convention, International Amphitheatre and Hotel Sherman, Chicago, Apr. 7-10.

International Conference on Fracture, Sponsors: Air Force Office of Scientific Research/Solid State Sciences Div., Office of Naval Research, National Science Foundation, National Academy of Sciences/NRC, Massachusetts Institute of Technology, Cambridge, Mass., Apr. 12-16.

Air Force Association, World Congress of Flight, Las Vegas, Apr. 12-19.

Aeronautical Training Society, 17th Annual Meeting, Desert Inn, Las Vegas, Apr. 16-17.

Institute of Radio Engineers, 11th Annual Southwestern Conference and Electronics Show, Dallas Memorial Auditorium, Dallas, Apr. 16-18.

Third National Conference, Aviation Education, Riverside, Calif., Apr. 17-18.

Institute of Radio Engineers, Spring Technical Conference on Electronic Data Processing, Cincinnati Section, Engineering Society Bldg., Cincinnati, Apr. 21-22.

Institute of Environmental Engineers, 1959 Annual Meeting, La Salle Hotel, Chicago, Apr. 22-24.

American Society of Mechanical Engineers, First National Metals Engineering Conference, Hotel Sheraton-Ten Eyck, Albany, N.Y., Apr. 29-May 1.

American Rocket Society, Controllable Satellite Conference, Massachusetts Institute of Technology, Cambridge, Apr. 30-May 1.

MAY

Air Force Office Scientific Research/Chemistry Div. and Electromechanical Society, Symposium on Electrode Processes, Philadelphia, May 3-7.

Institute of Radio Engineers, 11th National Aeronautical Electronics Conference, Dayton, Ohio, May 4-6.

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4

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MAGAZINE OF WORLD ASTRONAUTICS

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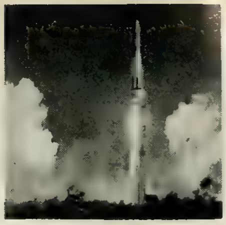
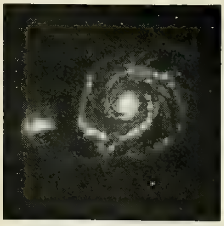
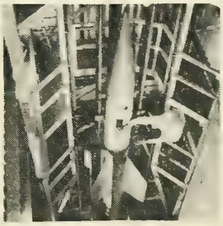


COVER: With three successful flights in succession, Martin's *Titan* ICBM soon will go into second stage testing.



NASA is planning to send a minimal rocket to the edge of the solar system in a test of long-range communication (p. 19).

SUPPORTING Project *Argus* (see third article by Prof. Fred Singer on p. 21) are *Jason* research rockets.

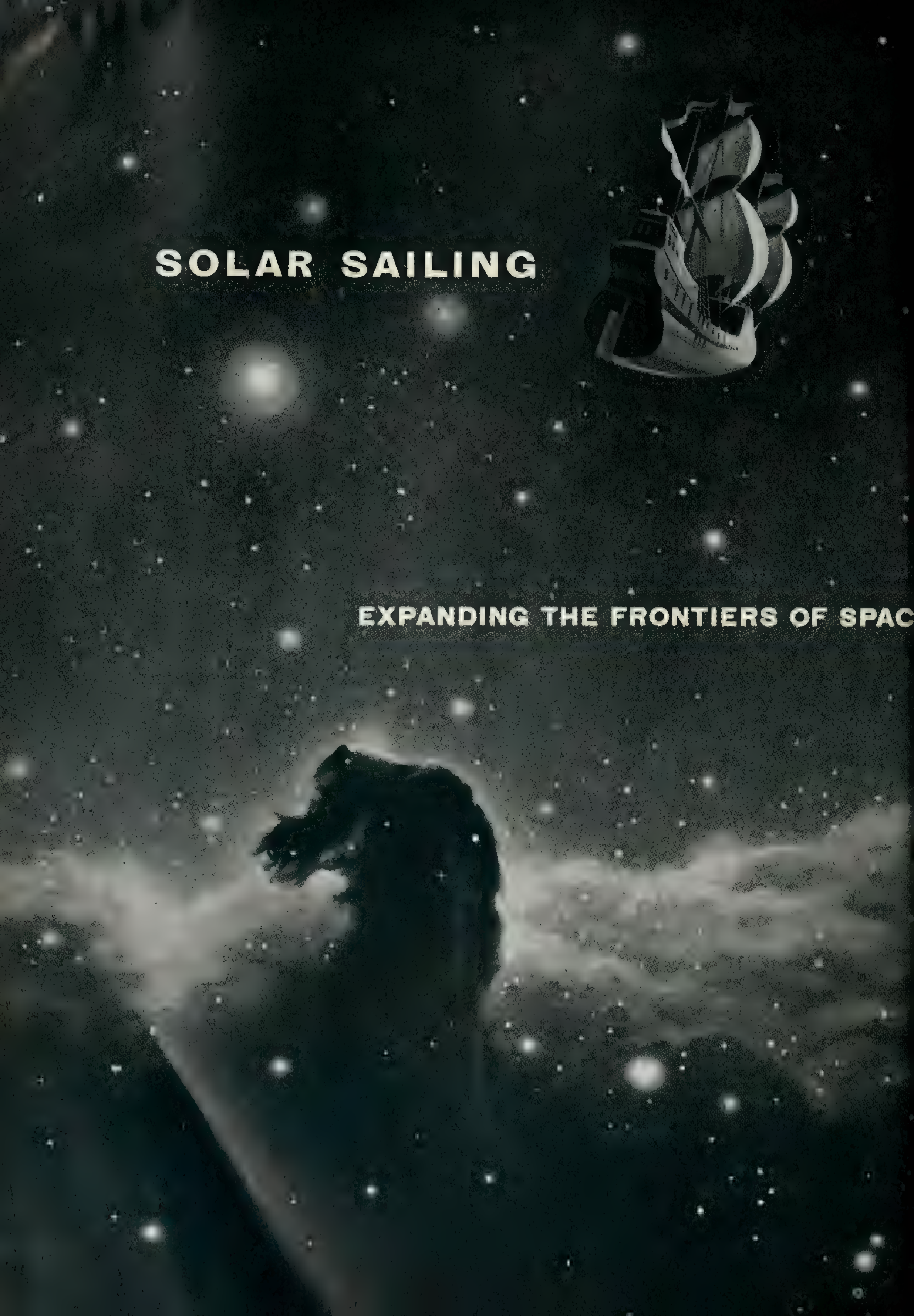


BRITAIN's *Thunderbird* undergoes six foot drop test to simulate shock of launching at English Electric's facility.

S.E.P.R. F32 solid-fuel motor undergoes test. S.E.P.R. well-known for its liquid work now is heavily engaged in solids (p. 28).

SOLAR SAILING

EXPANDING THE FRONTIERS OF SPAC



SOLAR SAILING: Space travel with the aid of solar radiation pressure—an area of advanced research at Lockheed. Vehicle would employ a sail that would be raised and lowered in flight. The artist has depicted Magellan's ship "Trinidad" to symbolize man's great voyages of discovery.

ECHNOLOGY

Lockheed Missile Systems Division is engaged in all fields of missile and space technology—from concept to operation. Advanced research and development programs include—man in space; space communications; electronics; ionic propulsion; nuclear and solar propulsion; magnetohydrodynamics; computer development; oceanography; flight sciences; materials and processes; human engineering; electromagnetic wave propagation and radiation; and operations research and analysis.

The successful completion of programs such as these not only encompasses the sum of man's knowledge in many fields, but requires a bold and imaginative approach in areas where only theory now exists.

The Missile Systems Division programs reach far into the future. It is a rewarding future which men of outstanding talent and inquiring mind are invited to share. Write: Research and Development Staff, Dept. D2-29, 962 W. El Camino Real, Sunnyvale, California, or 7701 Woodley Avenue, Van Nuys, California. For the convenience of those living in the East or Midwest, offices are maintained at Suite 745, 405 Lexington Avenue, New York 17, and at Suite 300, 840 N. Michigan Avenue, Chicago 11.

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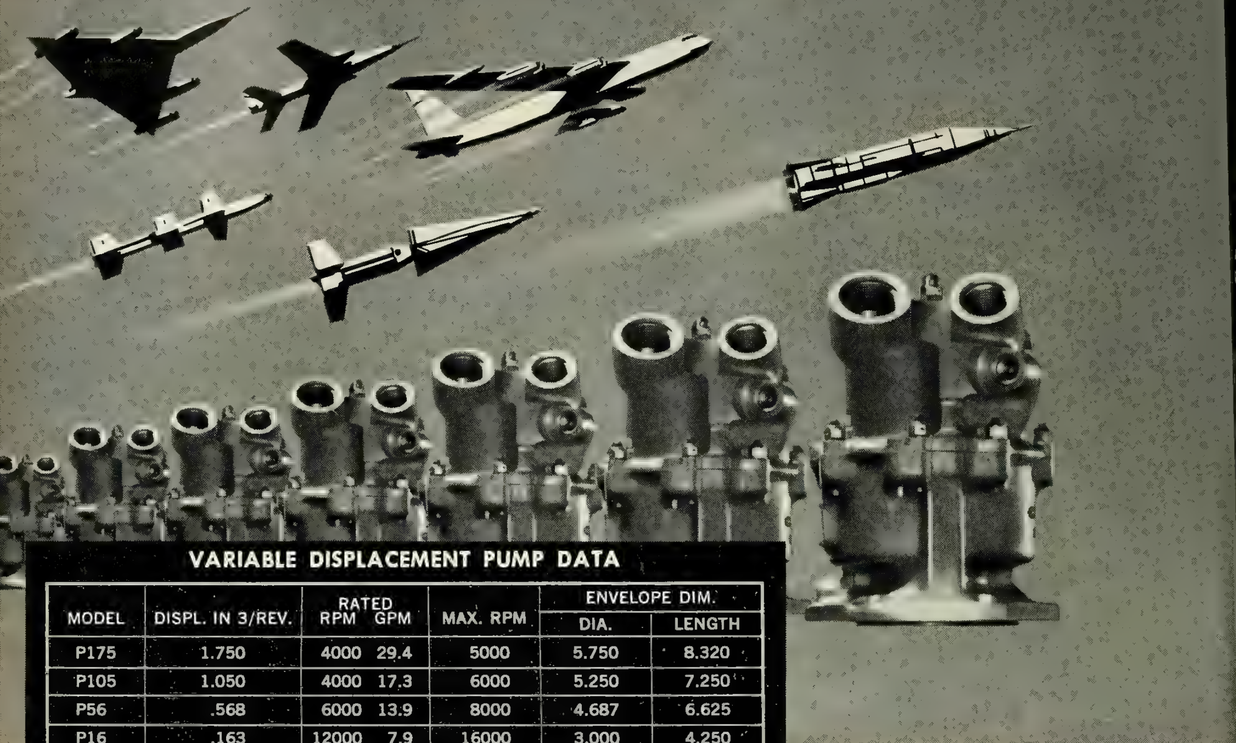

VARIABLE DISPLACEMENT PUMP DATA

MODEL	DISPL. IN 3/REV.	RATED RPM	RATED GPM	MAX. RPM	ENVELOPE DIM. DIA.	ENVELOPE DIM. LENGTH
P175	1.750	4000	29.4	5000	5.750	8.320
P105	1.050	4000	17.3	6000	5.250	7.250
P56	.568	6000	13.9	8000	4.687	6.625
P16	.163	12000	7.9	16000	3.000	4.250
P11	.115	12000	5.5	16000	2.750	3.625
P064	.064	12000	3.1	18000	2.125	3.125
P044	.044	12000	2.1	18000	2.125	3.062

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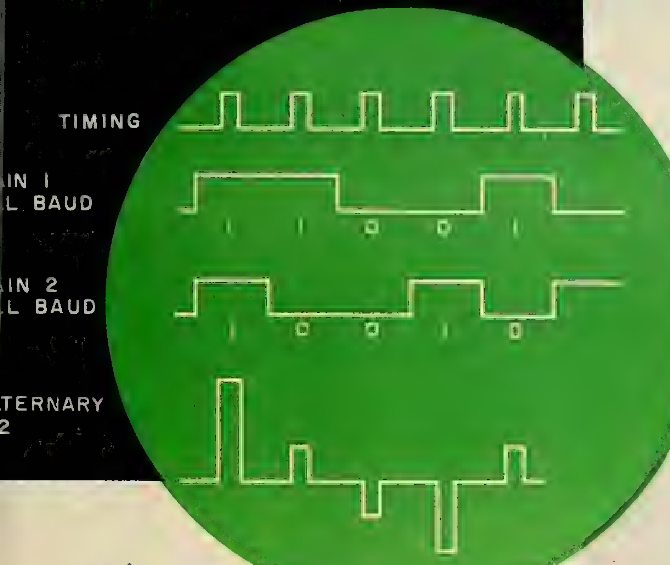
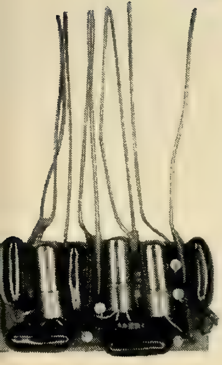
PULSE CODE MODULATION

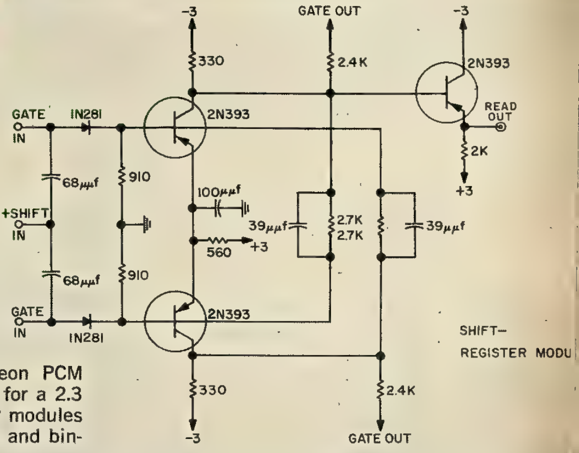


PCM is a new method of coding voice and analog information into digital form. It provides a completely digitalized message by time-division multiplexing of voice circuits. Adaptation of the technique offers advantages in signal-to-noise characteristics, signal regeneration, message security and equipment reliability not usually achieved with conventional techniques.

A 96-voice channel, fully transistorized PCM equipment for cable and radio transmission meeting rugged military requirements is now being developed by the Communications Department of Raytheon's Government Equipment Division. In this system a sampling frequency of 8,000 cycles is used. Each sample is coded in six-bit binary form, at a bit frequency of 4.6 mc. Many new circuit techniques, closely allied to high-speed data processing and computer systems are being developed for this equipment.

THE QUATERNARY WAVE combines information from trains 1 and 2, and the timing pulse regulates the width and position of the quaternary output wave. Thus, twice as much information is passed through the same bandwidth as is required for one train.





TYPICAL MOLDED MODULE used in Raytheon PCM equipment comprises logic circuitry required for a 2.3 mc shift register shown in the diagram. Other modules are used for repetitive and-or gates, flip-flops and binary-storage elements.

NEW OPPORTUNITIES WITH A FUTURE

Your background in design, development, production or manufacturing of radar, sonar, infrared, communication or countermeasure equipment may qualify you for an engineering future with Raytheon. Please write to Donald H. Sweet, Professional Personnel, Raytheon Manufacturing Company, Government Equipment Division, Wayland, Massachusetts.

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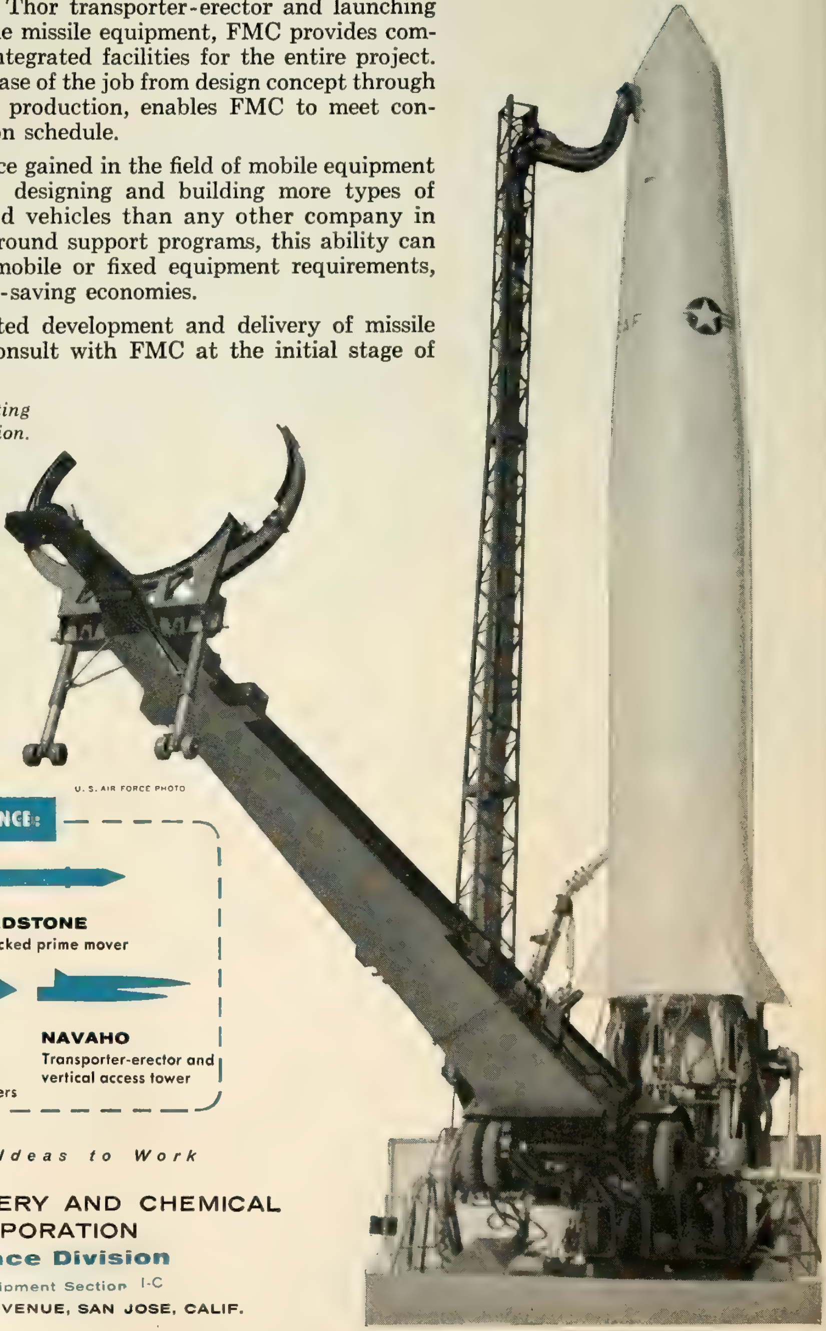

THOR transporter-erector, launching base and power trailer delivered by FMC in just eight months—2 months ahead of schedule—receives operational check-out.

U. S. AIR FORCE PHOTO

HERE IS FMC'S PROFILE OF EXPERIENCE:

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ARPA—A Dangerous Compromise

We think it is about time that Congress and the Defense Department sat back and took a long look at the Advanced Research Projects Agency (ARPA) and what its present work in the military field is doing to the U.S. military posture.

ARPA is responsible for all military space activity. The services have no money budgeted for this purpose. They do, however, have a great deal of responsibility in this field because—whether or not the fact is easily visible at the moment—there is little doubt that controlling accessibility to space in the future will be tantamount to controlling the earth.

ARPA was born of political expediency and is essentially a creature of indecision. When the Space Age dawned and the first *Sputnik* circled in the heavens, all three services leaped into the missile and spacecraft business with both feet and an eye to the future. From the resultant melee of *Vanguards* and *Explorers, Jupiters* and *Thors,* claims and recriminations came the plea for a definition of the roles and missions of the three services in space business. What portions rightfully and logically belonged to the Air Force, to the Army and to the Navy?

For reasons of its own the Administration sidestepped the problem by establishing ARPA—now self-styled the "Fourth Service," the "Space Service" or whatever you like. ARPA is by name an advanced research agency. In actuality 75 and more per cent of its activities are in the military space field and its prime function is to solve the roles and missions problem without really making it necessary for the Administration to come to grips with it.

ARPA solves it by dividing up the development of any one project between two or three of the services with the idea that once developed the hardware will then be given to the service needing it most. This assumes that one service, at least, will a) want it and b) be prepared to use it. Roy Johnson, director, defined ARPA's role on March 26 of this year, saying:

"To date, ARPA has been performing its work (all military space projects) by assigning its projects, or parts thereof, to one or more of the service organizations, and in a few cases, to other government agencies for execution either directly or on behalf of ARPA. For effectiveness and efficiency of operation, they are assigned to the lowest organizational unit which has the necessary facilities, personnel, and contractual and other delegated administrative authority to do the best job for us. For example, rather than assigning work to the secretary of the military department, which in turn would have to select and assign it to lower levels within the department, ARPA directly assigns the work to such lower organizations as the Air Research and Development Command in the Air Force, the Army Ordnance Missile Command and the Chief Signal Office in the Army, the Bureau of Ordnance and the Office of Naval Research in the Navy. The secretary of the department concerned and the Joint Chiefs of Staff are advised prior to the time of assignment."

Aside from the fact that Johnson and his people are assuming a greater knowledge of the capabilities of the services than the heads of the services themselves, the ARPA system is leading toward a conclusion which may be disastrous in terms of two things—time and money.

This is because the ARPA method of using a combination of services in development fails entirely to take into consideration the fact that space vehicles are intricate, highly technical pieces of equipment which require especially trained operators, special maintenance and special logistics. Such training, maintenance and logistics cannot be arranged for after the article goes into production but must be planned and carried out to coincide with progress in development. The men, the sites and the support equipment must be ready when the first article comes off the production line.

At the moment, ARPA is developing a communications satellite. The Air Force has the booster, the Army the transmitter and the Navy the tracking. Unfortunately, however, the article being developed is a compromise which exactly suits the needs of none of the three services. Even if it did, no service has been assigned to carry out the advance preparations for its utilization.

Obviously, the roles and missions of the services are a difficult problem and it would take calm judgment and political fortitude to decide them. But the present compromise may turn out to be more costly than we can afford.

Clarke Newlon

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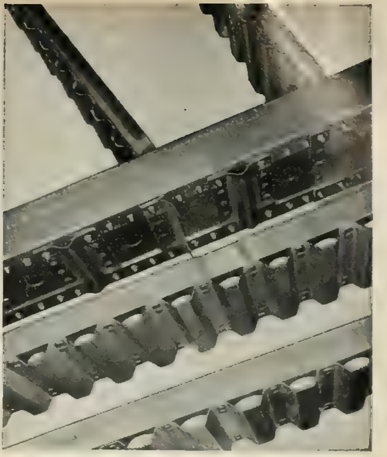

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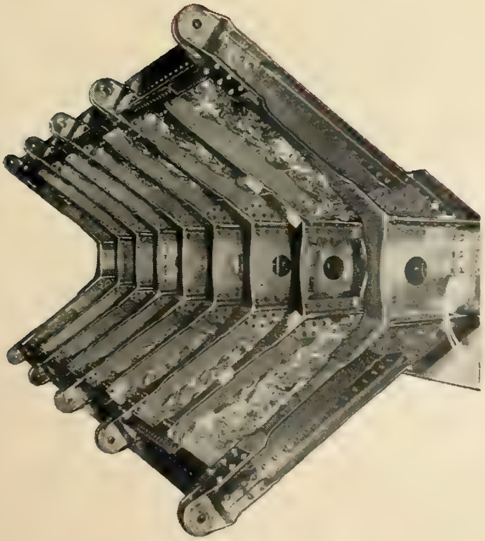
Contact your Engineering Standards Group or write to us for specific fastener data.



WING ATTACH STRUCTURE IS ASSEMBLED WITH INTERFERENCE FIT HI-SHEAR RIVETS. THE HS128 PINS ARE 17-4PH STAINLESS STEEL, HEAT TREATED TO 120,000 PSI MINIMUM SHEAR. THE HS91 AND HS92 PINS ARE A-286 ALLOY, HEAT TREATED TO 95,000 PSI MINIMUM SHEAR. BOTH PINS USE HS60M R MONEL COLLARS.

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NEW DEPARTURE

DIVISION OF GENERAL MOTORS, BRISTOL, CONN.

NOTHING ROLLS LIKE A BALL

washington countdown

IN THE PENTAGON

The era of push-button war is coming ever faster. A military crew successfully fired a Douglas *Thor*. Total countdown time: 17 minutes.

• • •

Not even the advent of Boeing's solid-propellant *Minuteman* in the next few years will necessarily eliminate the need for Convair's *Atlas* and Martin's *Titan*. The reason is the size of their warheads. The *Minuteman* will pack about one megaton . . . the *Atlas* about four. And the bigger warheads are needed to destroy a hardened missile base or nuclear factory.

• • •

Even the insiders are having a hard time forecasting the new line-up of the Air Force's top staff. With Secretary McElroy sitting on the list of promotions and assignments there are too many uncertainties. All three services, for instance, are debating whether or not to give up voluntarily a few four-star positions before Congress moves in and demands more. Air Force would like to give a fourth star to Lt. Gen. Emmett "Rosy" O'Donnell, now chief of personnel, but one senator is blocking it and she's adamant. And, Lt. Gen. Clarence Irvine, deputy chief of staff-materiel, resigned despite a request from AF Secretary James Douglas to stay on at least another year.

• • •

Irvine's post will probably go to his deputy, Maj. Gen. Mark Bradley. Deputy Chief of Staff-Personnel is most likely to go to either Lt. Gen. William Hall, now boss of Continental Air Command, or to Maj. Gen. Sory Smith, formerly chief of AF information and now commander of 4th Air Force at Hamilton AFB.

• • •

Gen. Laurence Kuter, present commander of Far East Air Forces, will go to North American Air Defense Command (NORAD). Gen. Frank Everest, now chief of the U.S. Air Forces Europe (USAFE), reportedly has asked for the Tactical Air Force, improbable as that may sound to many. Three of the top U.S. jobs, SAC in Omaha and Deputy Chief for Operations and Deputy Chief for Plans, both in the Pentagon, will stay with their present incumbents—Gen. Thomas S. Power, Lt. Gen. Dean C. Struther and Lt. Gen. John K. Gerhart. Should Rosy O'Donnell acquire the fourth star through some compromise with the senator, he probably would get USAFE, otherwise he will retire.

ON CAPITOL HILL

The Senate Space Organization Subcommittee will resume its investigation tomorrow on possible crippling rivalry among federal space agencies. Among the key witnesses: Pentagon R&D Director Herbert York. Among the key questions: Who is running the store?

• • •

The House Information Subcommittee is prodding the Pentagon to explain why it is restricting information about space monkey experiments on security grounds. The real reason is reported to be diplomacy—not security. India is understood to have put pressure on the State Department to stop all space monkey business because it offends Indian monkey worshipers.

• • •

Some Congressmen are talking in terms of adding a $1 billion package to the FY 1960 defense appropriations bill. The package would include extra funds for *Minuteman*, *Titan* and *Polaris* as well as *Atlas*.

AT NASA

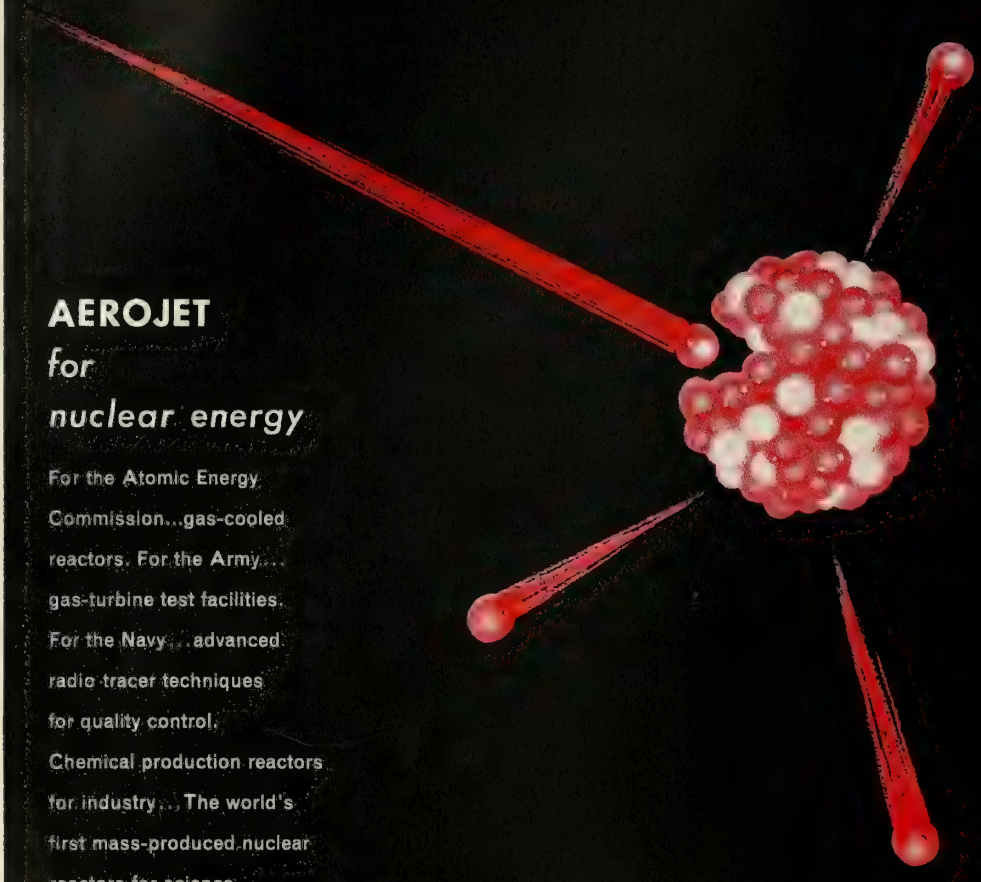
Vanguard III which is scheduled to be launched today will carry: (1) a 30-ounce precision magnetometer, (2) an inflatable plastic and aluminum balloon, and (3) a new third stage built by Allegheny Ballistic Missile Laboratory. The 30-inch balloon will be inflated with nitrogen when the payload separates from the third stage.

• • •

The *Vanguard's* new third stage is expected to greatly increase the life span of the *Vanguard* program. The solid-propellant rocket will triple *Vanguard's* payload capability.

AROUND TOWN

Gen. Lauris Norstad says the greatest need of NATO forces is modern weapons which must come from the U.S. under a plan carrying to 1963. He discounts the possibility of a limited war in Europe; says there are no present plans to train West Germans in the use of the IRBM simply because other nations are available; feels strongly that a disengagement in Europe as proposed would greatly dilute security of West; and believes NATO strength lies in its mutual consultations and ability to overcome disagreements.



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industry countdown

STRUCTURES

Martin's two-stage solid *Bold Orion* air-launched ballistic missile under WS-169A went more than 1000 miles April 3 when launched from B-47 in its fourth successful air drop. Word is that no other companies have yet achieved the Martin range. One of the hottest competitions which will mean a volume production item, WS-169A probably won't be decided until after July 1. It's interesting that Gen. Thomas D. White has commented that the system will have the same accuracy as ground-launched ballistic missiles.

• • •

Insiders say Pan American will receive Navy contracts to operate Pacific Missile Range stations at Guam and Midway. Other major contracts are reported in the mill for PMR development of Point Arguello, Hawaii and several other sites.

• • •

Rigid specifications can be expected in the DOD's quality control system uniform requirements coming out in about a month. Aim is for greater component reliability, with government monitoring control systems to be devised by contractors.

• • •

ADOS (Astronautical Defensive-Offensive System) is being unveiled by Avco at the World Congress of Flight. Developed for AF, system is still in the laboratory stage. It is designed to be an all-round weapons system to protect vehicles from attack or "piracy" in space.

• • •

Creation of a new "Bureau of Submarines" is being urged by Connecticut's Sen. Thomas J. Dodd. He wants a fleet of 100 missile-carrying atomic-powered submarines.

• • •

Watch for Supreme Court decisions in three cases involving the constitutionality of Industrial Security Regulations which allow DOD to force contractors to fire employes by barring them from classified material. Court will rule on ISR screening procedure which denied employes right to cross-examine their accusers.

PROPULSION

Significant advance in storable liquid propellants is indicated by North American's Rocketdyne Division. Firm discloses firing of all its production and experimental rocket engines with storables. Results: performance equal to or "slightly better" than standard LOX/RP with conversion factor "straight forward and relatively inexpensive.'

ARPA and DOD's Materials Advisory Board are slowly overcoming "inertia" in push for ultra-high thermal basic research. MAB solid rocket materials report is due May 15. Six other studies are in the works. Importance of investigating 10,000-60,000°F "Hell's fire" is pinpointed by Temple University's Dr. Aristid V. Gross. He says Russians are probably working in the field and could come up with "surprises" in search for new fuels and high-temperature materials.

• • •

Centaur and *Rover*—both users of liquid hydrogen—apparently are behind NASA's decision to go ahead with West Coast production unit for the material. Linde Co., a division of Union Carbide, won the 5-year contract to make about 2 million pounds of liquid hydrogen a year at its Torrance, Calif., plant.

ELECTRONICS

As space exploration increases, problem of shrinking radio spectrum for telemetry gets more acute. Attempts to find a solution appear likely to founder in politics. Eisenhower Administration has countered proposed $150,000 House study of problem with one of its own. They boil down to conflict over government vs. commercial preemption of bandwidths, with Congress leaning toward commercial side. If and when investigations get off the ground, telemetry needs may get shoved aside by VHF vs. UHF-TV hassle.

• • •

Industry experts believe big effort is required now in developing infrared techniques. Trouble is, says R. W. Powell of Aerojet-General's Avionics Division, "we know 90% of the physics of IR but only about 5% of its application."

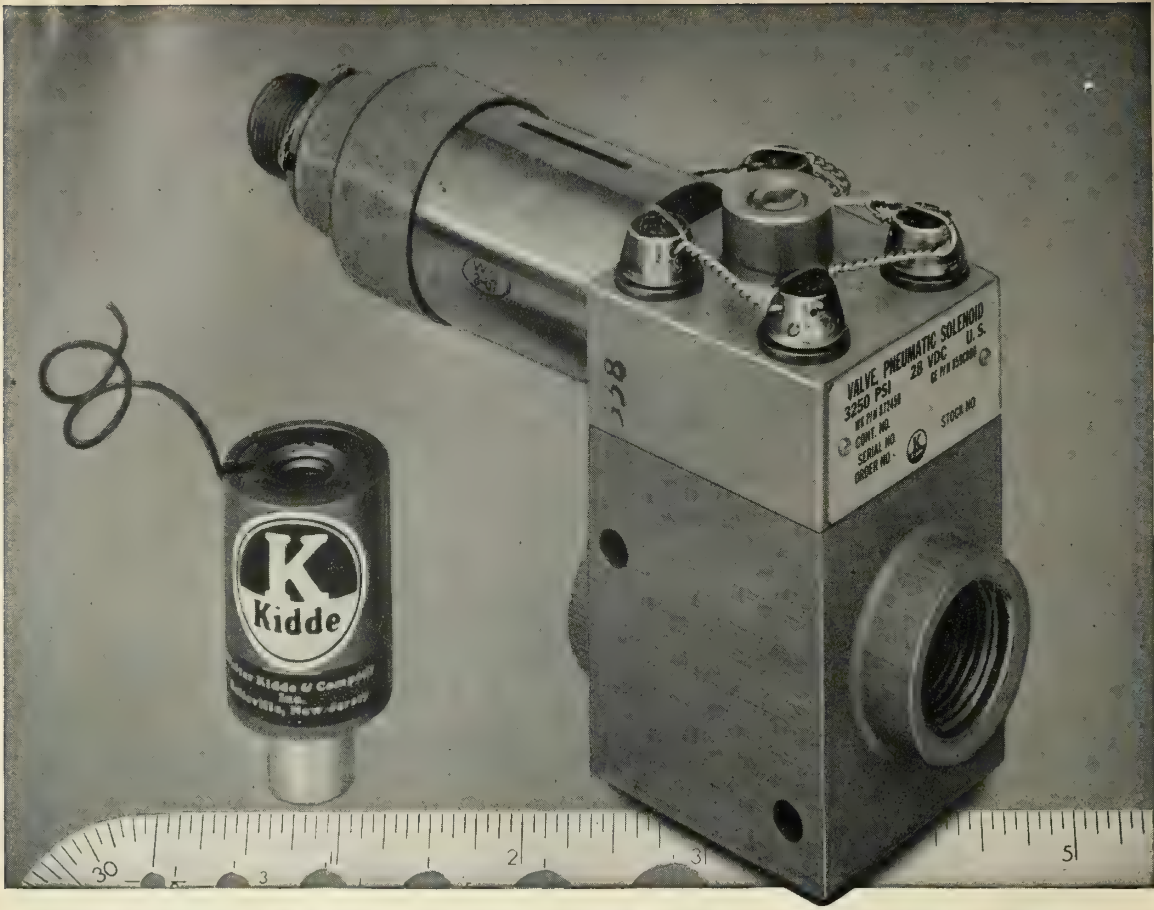
ASTROPHYSICS

An attempt to observe Venus from a balloon at 80,000 feet will be made by Navy this summer. Project will be similar to one last November to observe Mars. That one failed when balloon ripped. Two-man team hopes to determine whether there is water in Venus' atmosphere.

SPACE MEDICINE

Psychophysiological studies of stresses encountered in manning space vehicles are continuing at Duke Medical Center under a new $80,000 AF grant. The Center is trying to plot expected human reactions to monotony, close confinement, etc. of space travel.

More about the missile week on page 39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Leakage	3 cc/hr.
Flow	Equivalent to .05 orifice.
Operating Current	.5 to 1.5 amps.
Operating Voltage	14-30 V.D.C.
Mounting	by tubing support
Life	100 to 10,000 cycles depending on operating conditions.
Weight	.19 lbs.

KIDDE VALVE #872458 (The speed demon)

Operating Fluid	Dry air/nitrogen gas
Operating Pressure Range	80 to 3250 psi
Proof Pressure	4875 psi
Burst Pressure	8125 psi minimum
Ambient Temperature Range	−65°F. to +160°F.
Flow Factor	1.37
Voltage Range	18 to 30 V.D.C.
Current	(28 V. @ 80°F.) 1.2 amps.
Coil Resistance	(80°F.) 21.5 to 24 ohms
Weight	1.40 lbs
Response Time	0.018 seconds

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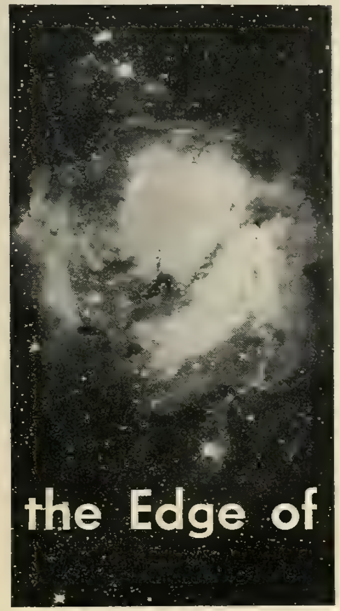
APRIL 13, 1959—VOL. 5, NO. 15

missiles and rockets

MAGAZINE OF WORLD ASTRONAUTICS



In 1962 NASA will fire minimal payload rocket and in next 8-10 years will perfect communications for receiving its data

To the Edge of Interstellar Space

by Hal Gettings

WASHINGTON—The National Aeronautics and Space Administration will launch a minimal rocket to the edge of the solar system in 1962. And during the eight to 10 years required for the probe to reach its destination, NASA will attempt to perfect communication techniques to receive transmitted scientific data back on earth.

The first hint of NASA's planning came several weeks ago from Eberhardt Rechtin, chief of the Guidance Research Division of JPL. Delivering a paper, "Communication Techniques for Space Exploration" at CalTech's Realities of Space Exploration Colloquium, Rechtin commented:

"Useful communication to the edge of the solar system can be achieved long before the space probe reaches that destination." He said the optimum time to fire for the edge of the solar system is about three years from now. Present or near-future rocket hardware makes such a venture feasible. However, the size of the payload undoubtedly will be small.

The rocket, which would probably have a cluster of 1.5 million pound engines for its first stage, would have to achieve a burnout velocity of over 14 miles per second in order to kick the instrument package towards the outer reaches of the solar system in the vicinity of Pluto.

The time that it would take the rocket to arrive at the orbit of Pluto, which is 2,668,000,000 miles from earth, would be over 4000 days.

Rechtin furnished the following facts:

- **Present solutions**—Worthwhile communication with space probes is achieved today with techniques not known before World War II. A greater quantity of useful information was obtained from *Pioneer III* with greater clarity, at greater ranges, and with better reliability than could even be conceived in 1950. Not only are these signals readable at levels millions of times smaller than with World War II radar receivers, but the signals themselves are more useful due to ingenious information coding techniques.

Pioneers III and *IV* produced considerably more useful information for the same power and bandwidth than was achieved even in the first *Explorer* probe fired less than a year before.

- **Immediate future**—It is easy to predict this nation's communications capability over the next several years (see table, p. 20). Characteristics of such extremely sensitive receiver configurations as the Microlock and the TRAC(E), of transistors, of parametric amplifiers, and of MASERS are so well understood that the only remaining controversy concerns how fast these developments might be incorporated.

The table shows effects of steadily increased transmitter power, increasingly stable vehicles with directional antennas aboard, and progressively more sensitive receivers on the earth. These capabilities are achieved with moderate-sized ground antennas of general utility. The illustration shows that television relaying around the earth is readily foreseeable and that useful communication to the edge of the solar system can be achieved long before the space probe reaches that destination.

- **Limitations**—There are several fundamental limits on communications capability, or at least on the rate of progress, and one is the overwhelming volume of data. For example, many hundreds of feet of trajectory information were teletyped from Puerto Rico back to JPL on one probe. This teletype information was fed into an IBM 704 which did rapid, real-time trajectory prediction for the positioning of antennas in the later stations.

Earlier, information of this type would have been presented as photographs of markings on an antenna pedestal which would have been laboriously read out by hand and still more laboriously entered into a computational procedure. Necessary as this amount of data was to obtain a precise orbit, this amount of information is small compared to the kind of information transmitted from a satellite surveying the earth.

Such satellites would transmit from 10^5 to 10^9 times as much information, all of which must be processed. There is some doubt whether any reasonable number of human beings could assimilate all this information in any reasonable time. Assimilation and data reduction almost unquestionably will have to be done by computers which present heavily reduced data to human viewers.

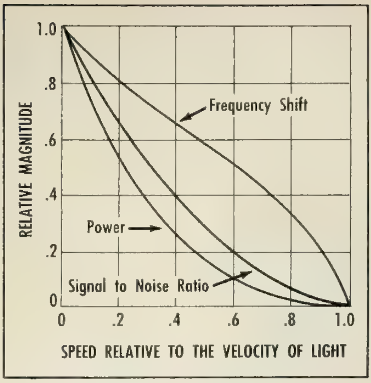
- **Noise**—Another limit is local noise. The earth itself, because it is warm (in effect, a "black body"), radiates noise which enters the system through the sidelobes of the antenna. There are several techniques under study for reducing this noise contribution.

One technique is to design antennas whose sidelobes are appreciably lower than that for conventional antennas. These so-called low-temperature antennas are in the early research phase only. Increased rejection of the earth's radiation by a factor of three might be possible, a factor of 10 would be outstanding.

Another proposal would shield the antenna from the earth by locating it in a valley and covering the whole valley bowl with a reflecting metal surface!

Another limitation is that imposed by the noisy atmosphere and galaxy. A low point in the combination of galactic and atmosphere noise occurs in the general region of 500 to 5000 megacycles per second. Galactic noise is strongly reduced as the transmission frequencies are increased, both because the galactic noise is less at these frequencies and because the galactic sources themselves become considerably smaller and more widely spaced.

The effect of the atmosphere is reduced by increasing the altitude of the station, avoiding looking at the earth's horizon whenever possible, and by keeping the transmission frequency something less than about 5000 megacycles per second.



EFFECT OF speed of receding vehicle.

- **Velocity**—The graph shows one of the limitations imposed by vehicles traveling at extremely high speeds. A relativistic phenomenon in communications occurs which is directly analogous to the forward beaming of energy when a near-relativistic electron collides with a stationary mass.

Even though energy appears to a moving observer to be radiated uniformly, the stationary observer thinks that the energy is all beamed forward. Therefore, for a vehicle rapidly receding from the earth at near the velocity of light, the apparent radiation back to the earth will be reduced significantly below that anticipated due to range alone.

In addition, the strong Doppler effect will make information arrive at a significantly reduced rate. Normal voice could sound like a 78 rpm record played at 33-1/3 rpm, as one example.

- **Time**—Another limitation is time. In exploring the region beyond the nearby planets, the time that it takes to reach the objective begins to stretch into years.

The amount of time that it takes to reach the destination is quite comparable to the time required to change the rate of the art in vehicles and communications. If a vehicle was launched today to the edge of the solar system there would not be a need for the extreme range communication system for some years to come.

LONG-TERM COMMUNICATION SYSTEM CAPABILITIES

CHARACTERISTIC	1958	1960	1962
TRANSMITTER POWER	0.1 W	10 W	100 W
VEHICLE ANTENNA GAIN	6 DB	16 DB	36 DB
RECEIVER SENSITIVITY (Noise Temperature)	2000°K	400°K	40°K
INFORMATION BANDWIDTH*			
1. Satellite Application	0.6 MC/S	> 10 MC/S	> 10 MC/S
2. Lunar Application	60 C/S	0.3 MC/S	> 10 MC/S
3. Mars Application	....	30 C/S	0.3 MC/S
4. Edge of Solar System	....	....	30 C/S

*Available bandwith for S/N = 10 DB assuming transmitter power, vehicle antenna gain, and receiver sensitivity as indicated above.

The table shows the edge of the solar system could be reached by 1960 as far as communications are concerned. Actually, however, since it will take between eight and 10 years to go that distance with a vehicle, the chart should be corrected to show the communications capability which might exist eight to 10 years from now, at least as far as the transmitting and receiving system on the earth is concerned.

Time scales of this sort also create the possibility that we should not fire this year with a minimal vehicle because if we fired next year with a better vehicle we would arrive at the destination sooner. But the optimum time to fire for the edge of the solar system, in order to reach there in the earliest year, is about three years from now. As for firing for the stars, it is evident ion drive is necessary and the communications engineer has at least four years to come up with an earth receiving system even if the vehicle left today at the speed of light.

- **Cost**—One of the final limitations is cost. Data acquisition facilities including antennas, buildings, and data handling equipment represent an appreciable capital investment. Whether or not the facilities needed for space communications are built is a question of economics. If the percentage return on the capital investment is high enough, money will be found almost independent of the absolute amount. It only remains to show that the space age is economically worthwhile.

As evidence of this, Rechtin pointed out several basic facts of the economics of the space age:

First, the success of the early *Sputniks* has probably cost the United States at least $5 billion which will be paid for in lost contracts on the world market, additional military and economic aid to allies, and increased demonstrations of U.S. military and economic might.

Second, it can be shown that it is more economic to use communication satellites for world communications than to use any other technique when the channel capacity desired approaches that of television or greater. The capital investment involved for such communications is about $300 million.

Third, during the past year there has been increasing interest by commercial organizations in sponsoring their own satellite program for purely commercial gain. The concerns would even buy the vehicles.

Nuclear Explosions in Space

- ***High-altitude blasts seriously interfere with radio and radar***
- ***Complete knock-out of electronic defense is unlikely***
- ***Artificial release of molecules could sweep up extra ionization***

Third of four articles by PROF. S. FRED SINGER

WASHINGTON—Radio communication and radar, including long-range detection and guidance, are seriously disturbed by atomic explosions at high altitudes. The radiations from the burst create a great deal of ionization which acts as a barrier to the propagation of radio waves.

In some cases the layer of ionization may absorb radio waves and thus interfere with communications. In other cases it will reflect radar waves and therefore shield from detection all objects above the layer.

The implications of these effects are important to upper atmosphere scientists; because of their relation to the anti-missile defense problem, they are also of concern to military planners and missile engineers.

In spite of the seriousness of the effects it is doubtful whether an electronic missile defense can really be knocked out completely by atomic bursts. One can always pick a high enough operating frequency for radio or radar to get around the effects of the extra ionization produced by atomic bursts, although this frequency may be far removed from the optimum. Other countermeasures may be possible—for example, scavengers which can sweep up the extra ionization in the upper atmosphere.

• **Statement of problem**—The whole problem can be divided into three parts:

1. The amount and space distribution of ionization is caused by the energetic radiations released in an atomic burst and is determined by the size and type of bomb, also the burst altitude in relation to the ionosphere altitude (50 to 300 miles).

2. The electrons which are produced by the burst affect propagation of radio and radar waves; therefore we must know what happens to them after creation. Various natural methods cause them to disappear, but the rate of disappearance depends on many factors, principally altitude. It may also be possible to remove electrons by artificial means, i.e., by releasing materials in the upper atmosphere following a burst.

3. Finally, the disturbing effect of the newly-created electrons on radio wave propagation should be studied. Extra ionization produced at very low levels, 50 miles or less, may cause absorption of radio waves while ionization produced at very high levels will act as a reflector of radio waves. While this may be useful in some cases (e.g., by improving ground-to-ground communications on VHF), the reflecting action will also screen missiles moving above this layer from ground radar. The question which must be answered quantitatively is how high a frequency is necessary for reliable operation at all times under all possible conditions.

As in the case of atomic effects on vehicles in space, there are two important cases of atomic bursts:

1. Effects produced on the upper atmosphere in *close vicinity* to a burst, This might occur in the explosion of a nuclear warhead of a defensive anti-ICBM missile. Or it may occur if an ICBM attack is preceded by an explosion of a large nuclear device whose purpose is interference with radar detection of the missiles which follow.

2. The second case has to do with the effects at *large distances* from the atomic burst due to radiation carried into the opposite hemisphere along the magnetic line of force. This may occur when an enemy wishes to interfere with communications at a point in the other hemisphere without the risk of invading that territory with his missiles.

• **Strategy of distant bursts**—There are some intriguing problems connected with the latter application. In fact, a proper appreciation of the physical situation determines the strategic use of long-distance atomic bursts.

In the April 20 issue: Nuclear Explosions in Space and How They Can Be Detected by a Great Variety of Scientific Techniques.

AEROLAB's *ARGO* E-5 research missile, here on launcher at NASA's Wallops Island station, was used in connection with Project *Argus*.

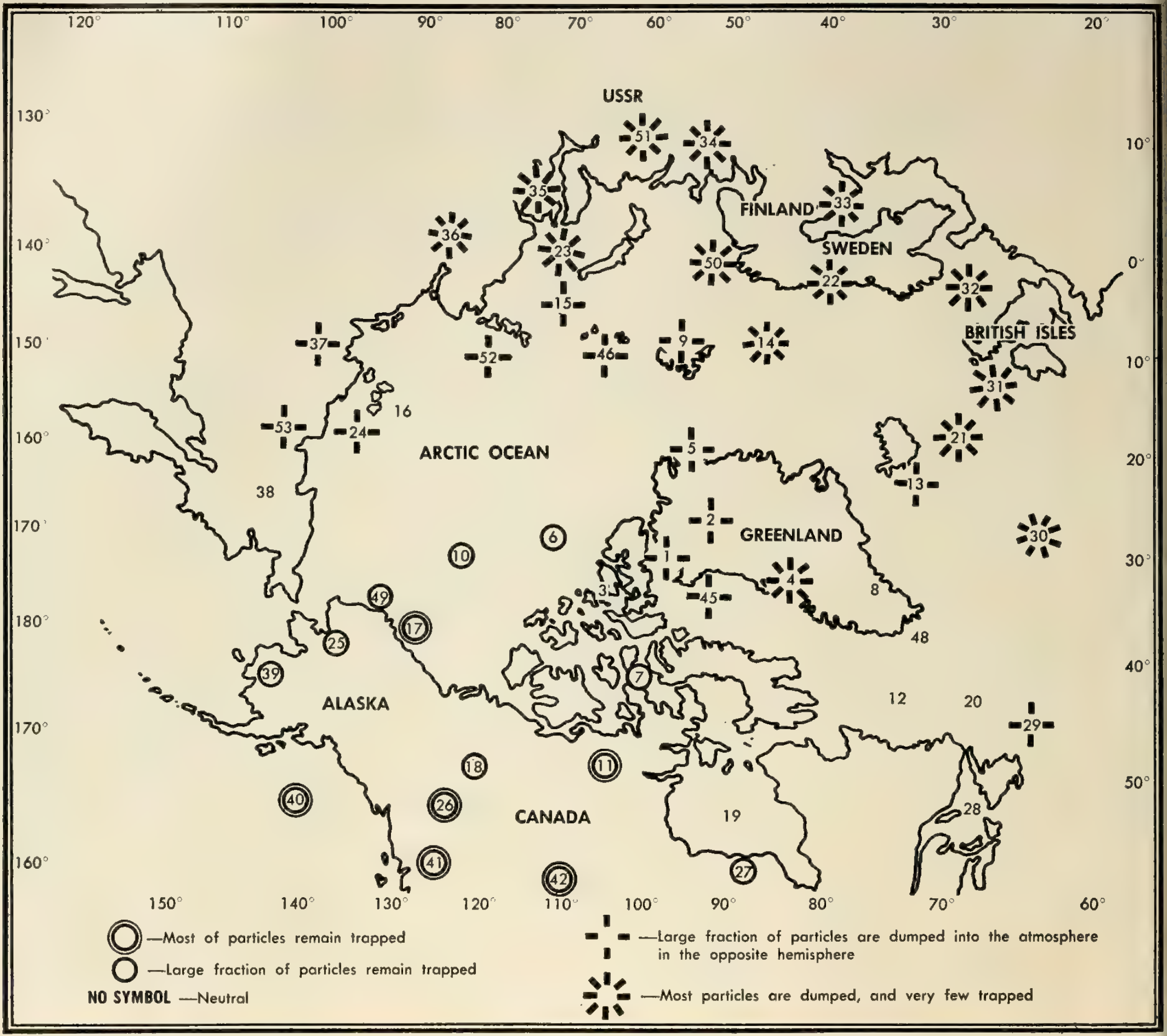


FIG. 1—Maps of the Northern and Southern Polar Regions. Numbered points show opposite end points of various magnetic lines of force. Each point has a code symbol (indicated on chart) showing effects of bomb burst at top of atmosphere.

It is obvious that particles emitted by the atomic burst will be "tied" to a line of force. But only the fission fragments and beta rays (electrons) are in fact guided by this line of force; the gamma rays and neutrons from the burst will escape.

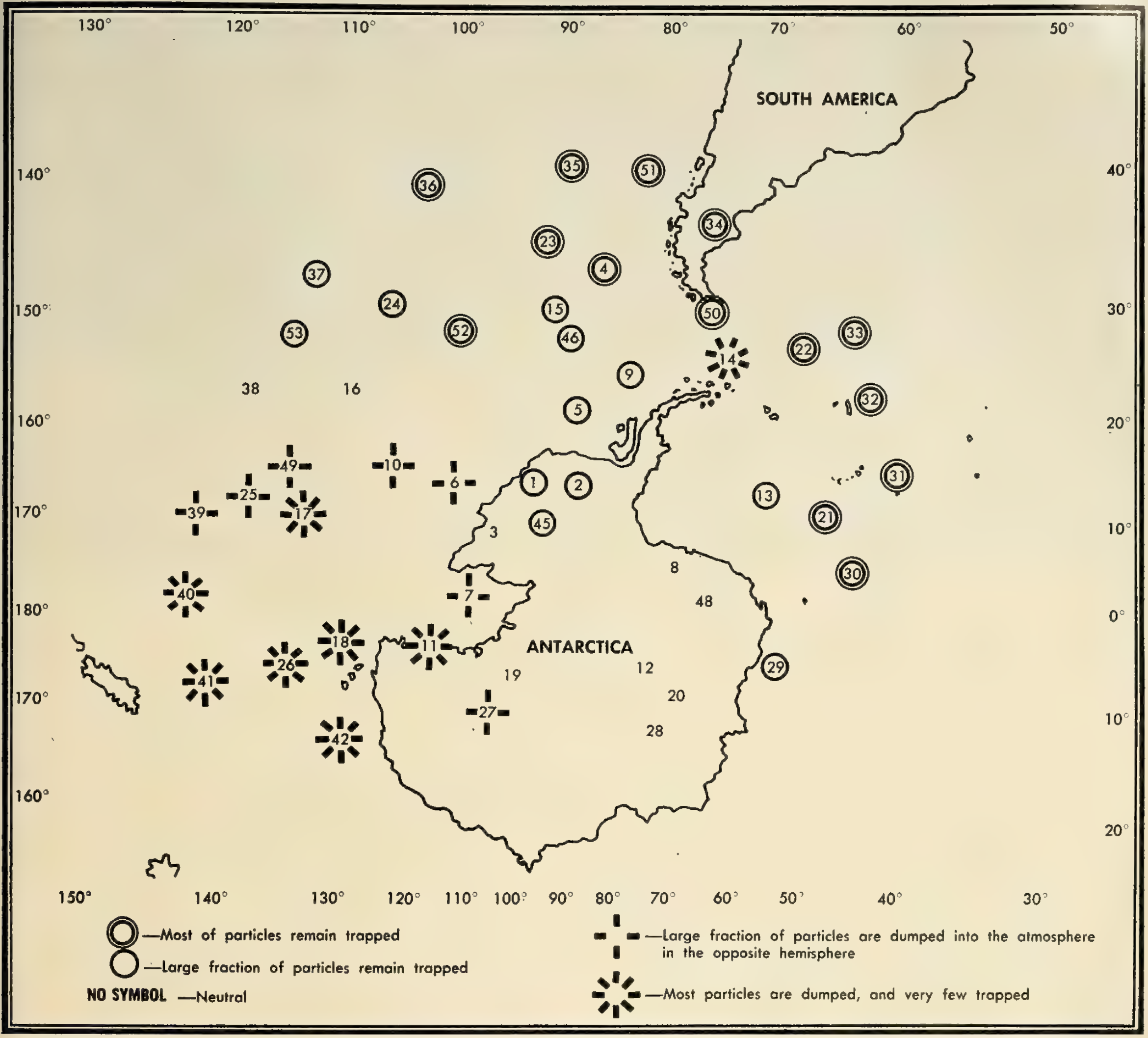
The earth's magnetic field has superimposed upon it various anomalies and the actual path of a line of force must be obtained from maps and calculations.

Fig. 1 shows the northern and southern polar regions and plots the end points of selected lines of force. The basic calculations were made by the Swedish physicists Block and Herlofson. Of course, these plots also show the point of incidence of radiation due to a distant burst point.

If the burst takes place at about 300 miles, very close to the top of the atmosphere, about half the energy is lost, since it will go straight down into the atmosphere at the burst point. But the other half is trapped along the line of force, propagates to the opposite hemisphere, and is dumped into the atmosphere.

If the aim is to dump the radiations of the atomic burst into the atmosphere in the opposite hemisphere, then the bomb burst should take place over a magnetic "high." In fact, if the magnetic anomaly is strong enough, one can transmit much more than 50% of the emitted energy by choosing a somewhat higher launching altitude and making use of reflection from the magnetic field below the burst. Fig. 1 indicates whether a burst at a given point will dump the radiations into the atmosphere, or whether they will remain trapped above the atmosphere.

• **Effects of close bursts**—It is quite difficult to calculate the distribution of ionization produced in the immediate vicinity of an atomic burst. All particles emitted in the burst generate ionization. These include fission fragments and neutrons, as well as gamma rays


SOUTH AMERICA
ANTARCTICA
Most of particles remain trapped
Large fraction of particles remain trapped
NO SYMBOL —Neutral
Large fraction of particles are dumped into the atmosphere in the opposite hemisphere
Most particles are dumped, and very few trapped
130° 120° 110° 100° 90° 80° 70° 60° 50°
150° 140° 130° 120° 110° 100° 90° 80° 70° 60° 50° 40° 30°
140° 150° 160° 170° 180° 170° 160°
40° 30° 20° 10° 0° 10° 20°

and beta rays from the subsequent decay of the fission fragments.

The situation is complicated because the actual position of the release point plays an important role. For release points in the lower part of the ionosphere, the effects of the magnetic field of the earth are of lesser importance.

The fission fragments cannot carry the ionization too far since they have a very short range, approximately 0.5 cm of air at normal pressure (equivalent to a thickness of 5×10^{-4} gram per cm^2 of material; entering from above the atmosphere they might penetrate down to approximately 100 km).

But the gamma rays and neutrons can penetrate over very long distances, and therefore produce ionization far away from the atomic burst, while betas are more confined—their range is limited, about 0.1 and possibly up to 1 gram per cm^2.

The most intense ionization is produced by the fission fragments: first, because they carry 90% of the energy, and second, because their much shorter range concentrates the ionization into a smaller volume.

A good rule of thumb is that each ionization of an air atom or molecule requires about 30 electron volts. Therefore the products of a nuclear fission, where 180 Mev of energy is released, can create something like 6 million electrons and ions. A 1 kiloton atomic bomb produces 1.3×10^{23} fissions, and therefore 8×10^{29} ion pairs.

If we assume the burst point at 60 miles* and use an average range of

---

**At this altitude, the three important lengths—range and radius of gyration of the average fission fragment, and atmospheric scale height—are all of the same order of magnitude. At other altitudes, this is no longer true and the problem is somewhat more involved. Our example cannot be applied to the Johnson Island tests of August, 1958, because of different conditions, e.g. use of a large H-bomb.*

about 5 km, the volume in which the greatest ionization is produced amounts to something like 500 km^3, giving an average electron density of 10^{12} electrons per cm^3, about a million times the ambient value.

This rather rough estimate can vary by orders of magnitude depending on the point of the explosion and other factors. But it indicates the extremely high electron densities producible near atomic bursts. In our present example, a large fraction of the neutral atoms become ionized.

To relate electron densities to radio frequencies, the plasma frequency (or critical frequency) of an ionized gas is given by

$$f_c = 8.97 \sqrt{n_e}$$

(in kilocycles), where n_e is the electron density per cm^3. Thus an increase in electron density by a factor of 10^6 over normal values implies an increase in critical frequency by a factor of 10^3. It places the critical frequency in the region of some 10,000 megacycles.

- **Effects of distant bursts**—It is easier to calculate the upper atmosphere effects produced by radiation guided by the earth's magnetic field. Only fission fragments and beta particles (electrons) can be guided in this way. The betas will arrive first and their total energy per fission (spread over several electrons) is of the order of 5 Mev, possibly less, since not all fission fragments will have decayed.

TABLE 1. PROPERTIES OF "NORMAL" ATMOSPHERE

ALTITUDE (km)	TEMPERATURE °K	N_2 cm^{-3}	O_2 cm^{-3}	O cm^{-3}	Ne cm^{-3}
50	270	2.0×10^{16}	0.5×10^{16}	....	......
60	253	5.8×10^{15}	1.5×10^{15}	....	......
75	203	7.6×10^{14}	1.9×10^{14}	....	......
100	210	4.3×10^{12}	8.5×10^{11}	1.7×10^{12}	5×10^{5}
200	900	2.0×10^{9}	1.9×10^{8}	7.8×10^{9}	2×10^{6}
300	1400	9.8×10^{7}	6.5×10^{6}	1.2×10^{9}	2×10^{6}

TABLE 2:
UPPER ATMOSPHERE IONIZING AND DE-IONIZING REACTIONS

1. PHOTOIONIZATION: Creation of an electron-ion pair by absorption of an ultra-violet photon; e.g. $O + \text{photon} \rightarrow O^+ + e$
2. IMPACT IONIZATION: Creation of an electron-ion pair by the impact of a very fast particle; e.g. N_2 + fission-fragment $N_2^+ + e$ + fission fragment
3. ATTACHMENT: Capture of a free electron by a neutral atom or molecule, mainly O_2; e.g. $O_2 + e \rightarrow O^-_2$. The rate coefficient for this reaction is 10^{-13}—10^{-14} cm^3/sec.
4. PHOTODETACHMENT: Detachment of an attached electron by the absorption of a photon; e.g. $O^-_2 + \text{photon} \rightarrow O_2 + e$
5. DISSOCIATIVE RECOMBINATION: Capture of a free electron by a positive molecular ion, followed by dissociation of the molecule; e.g. $N_2^+ + e \rightarrow N^* + N^*$. The rate coefficient is 3×10^{-8} cm^3/sec. which is quite large & gives a fast reaction.
6. RADIATIVE RECOMBINATION: Capture of a free electron by a positive atomic ion, followed by emission of a photon; e.g. $O^+ + e \rightarrow O + \text{photon}$. The coefficient is 10^{-12} cm^3/sec. which is quite small; hence the reaction proceeds slowly.

Nuclear Reactor in Space

It is interesting to consider the artificial radiation belt produced by operating a nuclear reactor, e.g. in a communication and reconnaissance satellite. If the reactor's power level is 100 kilowatts, and its orbit 1000 miles above the equator, then the following estimates apply: Number of uranium fissions about 6×10^{15} per second, which also gives roughly the number of escaping neutrons.

Assuming these to be of thermal energy then, they travel an average distance of 200 miles before decaying radioactively into an electron and proton. The electrons are released with a mean energy of 0.5 Mev into a volume around the earth of about 6×10^{25} cm^3. Taking a lifetime of a few days, their concentration builds up to 10^{-4} per cm^3, but their flux will be something like 10^6 per cm^2 per second, 100 times greater than the maximum flux of the natural radiation belt.

Fortunately it is easy to shield against 0.5 Mev electrons; the reactor therefore produces no hazard. However, the phenomenon of trapped radiation can be used to detect the existence of an orbiting nuclear reactor.

In studying penetration of these beta particles into the atmosphere, their exact energy spectrum is of course of great importance. The highest energy beta rays will penetrate much deeper than low-energy rays.

In addition, the penetration depends, but not too strongly, on the pitch angle of the arriving particle. A particle with 0° pitch angle, i.e., moving along the line of force, will penetrate deepest. (At high latitudes we may assume to a good degree of approximation that the lines of force are vertically incident on the atmosphere.)

For example, a 2 Mev beta particle has a range of about 1 gram per cm^2 and therefore can penetrate to 50 km altitude. But a typical fission fragment with a range of 5×10^{-4} gram per cm^2 will penetrate down to about 100 km.

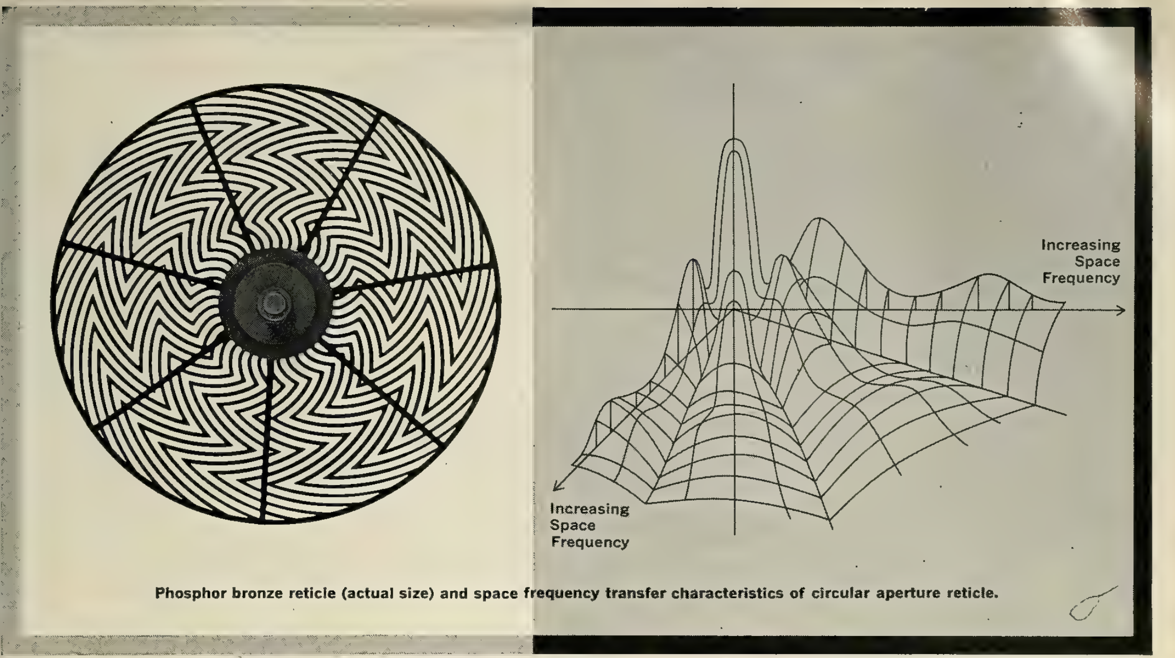
Some rough calculations can be made on the ionization produced by the incidence of these particles. Without specifying the distribution of energies of the beta rays and fission fragments, but for order-of-magnitude considerations, we will assume that the betas produce all of their ionization between altitudes of 50 and 100 km, while the fission fragments produce their ionization above 100 km up to about 200 km.

Using the basic data for a 1 kiloton bomb, recalling that only one-half of the particles are emitted into a direction where they can be carried by the magnetic field to the opposite hemisphere, and taking an area of incidence of approximately 1000 km^2, we derive the following electron density produced by the incidence of beta particles: about 2×10^8 per cm^3 in the region 50 to 100 km. This process requires in the order of 1 to 2 seconds.

It is followed a few seconds later by the arrival of the fragments. Detailed theoretical investigation reveals that their impact leads first to a compression of the ionosphere correlated with the ionization of the neutral components of the upper atmosphere. We are left then with an electron density of about 3×10^9 per cm^3 in the region of 100 to 200 km.

- **Removal of electrons**—The ionospheric problems raised by atomic bursts are very similar to those en-

(Continued on page 41)



Phosphor bronze reticle (actual size) and space frequency transfer characteristics of circular aperture reticle.

TARGET DISCRIMINATION IN INFRARED DETECTION SYSTEMS

The pioneering field of infrared detection offers many challenging opportunities to scientists and engineers at Ramo-Wooldridge for advanced studies in the solution of target discrimination problems. Research is continually under way at Ramo-Wooldridge in the integrating of infrared detection devices with the latest electronic systems techniques for enhanced target detection on the ground and in the air.

The phosphor bronze reticle, or image chopper, illustrated above was developed by Ramo-Wooldridge. It indicates a marked stride in space filtering discrimination concepts, and is used for target signal enhancement in guided missiles, anti-aircraft fire control and air collision warning applications.

The reticle is used in the focal plane of an infrared optical system and is rotated to chop the target image for the desired space filtering. It is also employed in time filtering, such as pulse length discrimination, or pulse bandwidth filtering.

Space filtering is critical to infrared systems, because of its ability to improve the detection of objects located in the midst of background interference. In a manner similar to that used in the modification of electronic waveforms by electrical filtering, space filtering enhances the two-dimensional space characteristics of a target. The size and features of the target are highlighted and the undesired background eliminated.

Scientists and engineers with backgrounds in infrared systems—or any of the other important areas of research and development listed below—are invited to inquire about current opportunities at Ramo-Wooldridge.

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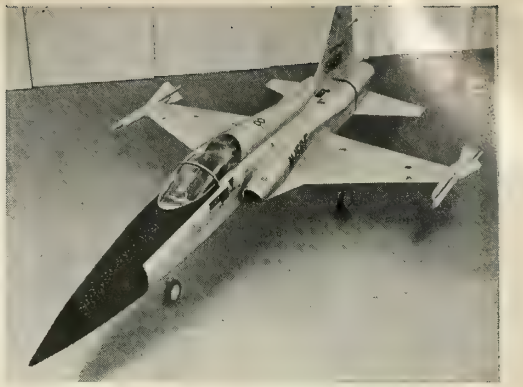

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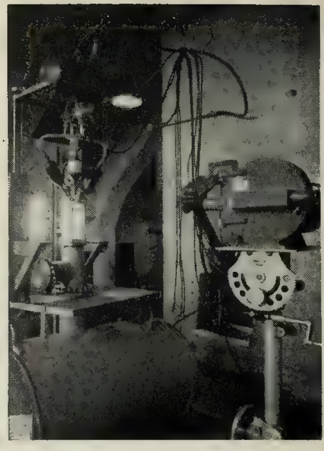
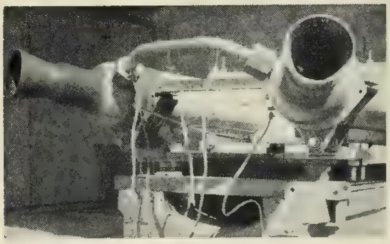
NORAIR

Test benches for liquid-propellant rockets.



Ignition test in transparent chamber.



Type 686 solid-propellant rocket.

FRENCH ASTRONAUTICS

S.E.P.R. test facilities are believed to be best on Continent; firm builds and tests both solid- and liquid-fueled engines

by Jean-Marie Riche

PARIS—S.E.P.R.—Société d'Etude de la Propulsion par Réaction—is fairly well-known for its unique experience in construction of small biliquid rockets used as booster engines on high-speed jet interceptors ("Trident" and "Mirage"). The extensive work conducted in this field by S.E.P.R. has now reached the production stage with the advent of the company's 841 model for use on the Dassault "Mirage III A" fighters.

Little is known, however, about the activity of S.E.P.R. in the field of solid-propulsion motors—this despite the fact that the company is the only one in Continental Europe to have built solid-propellant propulsion systems with an impulse of more than 100 tons/second, an achievement which is matched in the Old World only by Bristol in England. More than a thousand tests of such systems have now been made by the company, which has consumed more than 200 tons of solid propellants of miscellaneous descriptions.

Created in 1944 to study the techniques of jet propulsion, S.E.P.R. is exclusively a research company and has no facilities for mass production. Its headquarters have been established in a fort at Villejuif, a southeastern suburb of Paris, where all the research on solid-propellant rockets and on special projects (nuclear power, auxiliary powerplants, etc.) is conducted.

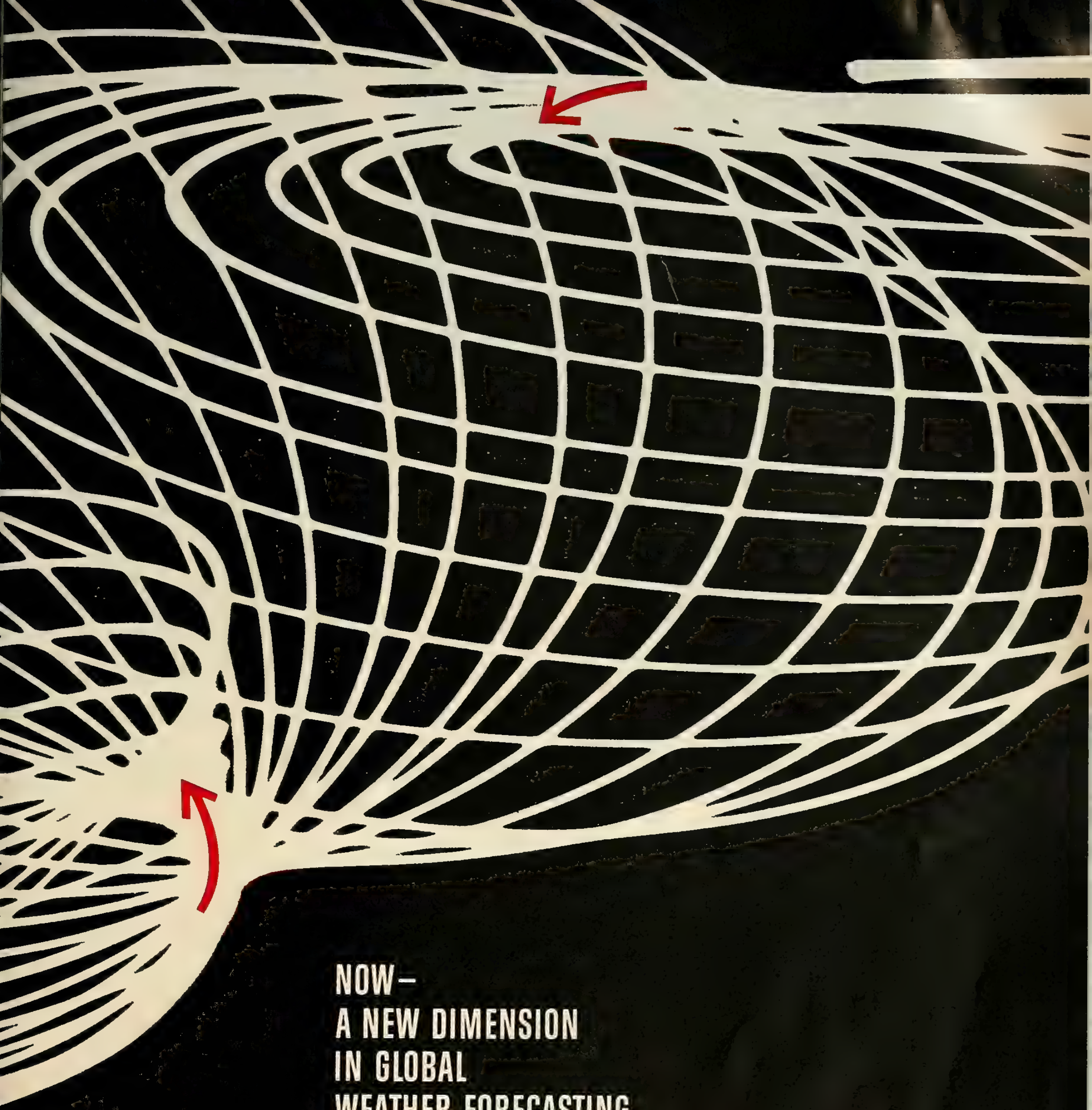
The engines designed at the headquarters are manufactured by a prototype shop in Argenteuil, a western outskirt of Paris. Liquid-propellant engines are tested at the center of Melun-Villaroche, where twelve test benches for propulsion units and six benches to test engine parts are installed. The center of Melun-Villaroche also includes a shop for the assembly and modification of power plants.

• **Heavy testing**—Finally, at the center of Istres, S.E.P.R. has created a maintenance and overhaul plant of aircraft rockets and test benches for solid-propellant engines. The company, which now employs 750 persons, has studied about 70 types of liquid- and solid-propellant engines. In addition to the tests conducted with solid-propellant rockets, 12,000 tons of nitric acid have been consumed during 45,000 tests with liquid-propellant engines.

The testing facilities of S.E.P.R. are believed to be unequalled on the continent. Besides benches for the measurement of thrust, the company operates stoves and cold chambers allowing tests between −22°F and +140°F, and acceleration benches on which 20g can be reached with a 330-lb. propulsion unit.

The company has built many measuring instruments whose precision and resistance are unique among products of the French industry.

S.E.P.R. is financially controlled by Sud-Aviation, the biggest French aircraft manufacturing company; Hispano-Suiza, an aircraft engine manufacturing company, and two of the main groups of the French chemical industry—Ugine and Air Liquide. The company does foreign (German, Italian) as well as French business.



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The instantaneous dissemination of up-to-the-minute and ever-changing weather data to the world-wide bases of the United States Air Force is a must in this space age. And the new Burroughs Electronic Teleprinter operating at speeds beyond 2,000 words per minute plays a key role in the Air Force's 433L Weather Observing System. Proof again of Burroughs leadership in another all-vital area of defense: high speed communications.

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MOMENT IN HISTORY

THIS IS THE "FIRST FLIGHT" of the new Air Force TITAN, America's most powerful weapon and our No. 1 challenger in the big-missile field. Time: 2/6/59—4:22 p.m. EST. The most important thing about this moment in history is not visible here—and it is this: Three years to the day from the breaking of ground at Martin-Denver, TITAN No. 1 roared into the sky. Those 36 months saw the creation of the free world's most advanced ballistic missile facility—and the development, production, testing, delivery and launching of the first of an entirely new *generation of ballistic missile weapon systems, forerunner of the Global Ballistic Missile. TITAN is the result of an advanced engineering concept—developed by Martin under the direction of the Air Force's Ballistic Missile Division of the Air Research and Development Command—which provides the most extensive pre-flight testing of components, subassemblies and full scale missiles ever undertaken. This method in the TITAN development, and in the generations of space systems to follow, may well be one of the most important single factors in speeding America's bid for space supremacy.*

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Seven Selected for NASA's Project *Mercury* Program

WASHINGTON—The National Aeronautics and Space Administration has reduced the number of astronauts to be used in the Project *Mercury* Man-In-Space program from twelve to seven.

NASA emphasized that the reduction was not caused by any unwillingness on the part of the candidates to take part in the program or because of difficulty in finding a greater number of qualified men.

A smaller number of astronauts was found to be desirable, NASA said, so that each could receive intense instruction in the engineering and scientific development of the vehicles, in the sub-orbital buildup missions, and in the techniques of the actual manned satellite flight.

The candidates were tested at the Lovelace Clinic in Albuquerque, N.M., and at the Wright Aeromedical Laboratories at the Wright-Patterson AFB. The seven astronauts will report in the near future to the Space Flight Activity at the Langley Research Center.

Tiny Photo Cells Provide Supersensitivity

NEW YORK—Small photo cells, one-quarter inch in diameter and one million times more sensitive than conventional vacuum tube types, will soon be produced by Clairex Corporation of Puerto Rico.

A. F. Deuth, president of Clairex Corporation, listed 12 different fields of application for the tiny photoconductors, including computers and data processing, industrial controls, medical electronics, aircraft and missiles.

Deuth predicted wide use of the new cells in photography. He noted that existing photo exposure meters and controls employing conventional photovoltaic cells have not kept pace in sensitivity with improvement in speed of films. However, he said a light sensitivity of greater than ten times is easily achieved with the Clairex cell, providing a sensitive area of less than 1/100 of the conventional type.

Polaris Test Amplifier Called World's Largest

BALTIMORE—A tremendous amplifier, capable of vibrating at predetermined frequencies, has been built for testing *Polaris* missile parts, Westinghouse Electric Corporation announced.

Described by its makers as the world's largest and most powerful amplifier, it has an output capacity of 200,000 watts and is valued at more

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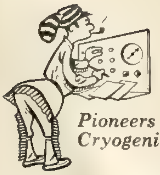
For more information write,
J. T. Reilly, Director of Marketing.



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than $100,000. It weighs approximately 10 tons and is 24 feet long, 7 feet high, and 3 feet wide.

W. J. Delaney, Jr., manager of the company's X-ray and industrial electronics division here, said the amplifier will be used by Lockheed Aircraft Corporation at its Sunnyvale, Calif., plant for testing components and sub-assemblies of the Navy's *Polaris*.

Instead of being connected to a conventional speaker system, the amplifier will cause a platform to vibrate. This platform is three feet in diameter and is arranged so that missile parts can be attached. It vibrates at the required frequencies for the same reason that the cone in a loudspeaker vibrates to produce sound.

Recorder Operates Far below Sea Surface

WESTBORO, MASS.—Development of an instrument that detects and graphically records underwater information has been announced here by Alden Electronic and Impulse Recording Equipment Company, Inc. Known as the "Precision Graphic Recorder," the device can be operated thousands of feet below the surface, according to the company.

The Woods Hole Oceanographic Institute, Woods Hole, Mass., aided in development of the instrument, which can be used in detection of submarines, studying temperatures and the formation of the ocean floor, and locating mineral and oil deposits. Details of the device were not described, but the company said "unusual techniques" of the recorder would make it useful in such fields as radar, ultrasonics, infrared, spectrum analysis, radio astronomy, satellite tracking, and propagation studies.

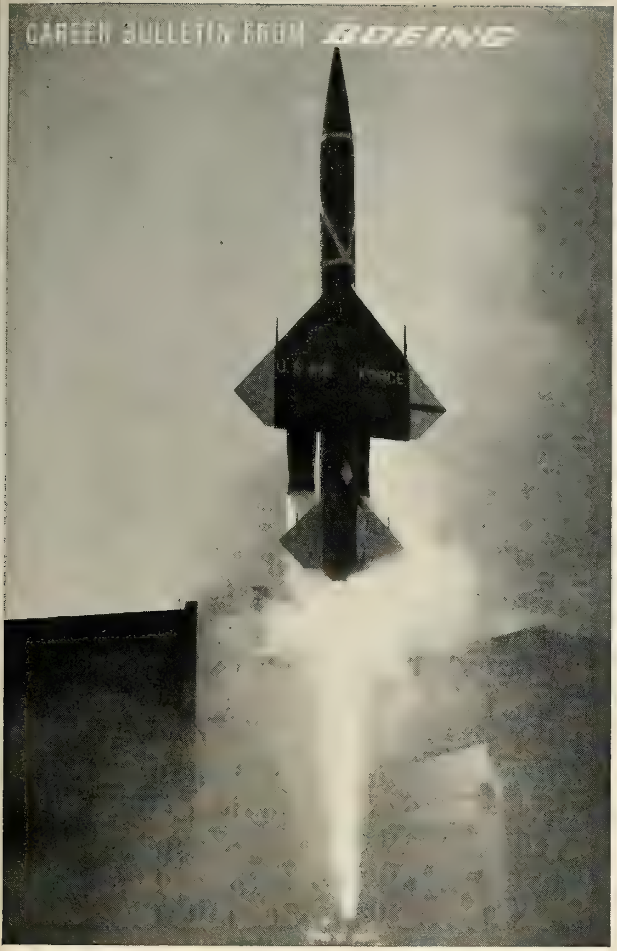
About the Cover

Titan A-4X is shown roaring off the launch pad April 3 in 300-mile shot testing its first-stage engine.

This was the third "successful" test within two months of the Martin Co.'s ICBM, which is 90 ft. long and weighs 110 tons. Rapid progress has brought *Titan* to the point where second-stage testing is about to start.

Engines for both stages develop 380,000 pounds of thrust and are made by Aerojet-General Corp. They are reported to be capable of pushing the big rocket with a nuclear warhead 9000 miles.

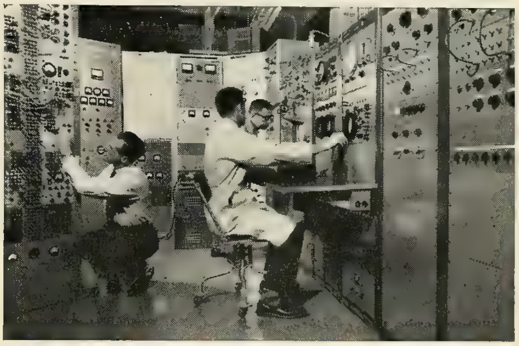
Earlier successful firings came on Feb. 6 and Feb. 25.



BLAST-OFF of supersonic Boeing BOMARC, the nation's longest-range defense missile. Now in volume production for Air Force bases under construction. Other Boeing missile projects that offer engineers and scientists outstanding career opportunities include Minuteman, an advanced solid-propellant intercontinental ballistic missile system.

SAILBOATS on Lake Washington in Seattle, boating capital of the U.S. Boeing headquarters are located in evergreen Puget Sound area, world famous for fresh and salt water boating, fishing, hunting, camping, scenic forests, dramatic snow-capped mountains, mild year-round climate. Wonderful Western living for the whole family!

SPACE-AGE projects are expanding at Boeing. Above is human factors laboratory in which problems of providing environments and controls for space vehicle crews are investigated. Celestial mechanics, lunar orbital systems and interplanetary systems are other areas that offer long-range space-age career opportunities to qualified engineers and scientists.



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Mahon to Demand More *Atlases*

by James Baar

WASHINGTON—Chairman George H. Mahon (D-Tex.) of the House Defense Appropriations Subcommittee favors greatly boosting production of *Atlas* to match Russia ICBM for ICBM during the next four years.

The powerful Congressional leader told M/R the deliberate decision by the Administration not to maintain ICBM parity with Russia would weaken U.S. deterrent power and would tend to shake "our confidence in ourselves and the confidence of our allies in us."

He said his subcommittee when it drafts the defense appropriations bill for FY 1960 would seriously consider adding hundreds of millions of dollars for more of the Convair missiles.

- **How much**—Mahon said he has yet to decide how much more he thought should be pumped into the *Atlas* program. But he made unmistakably clear that he favored attempting to match more or less Soviet ICBM production.

A number of key Congressmen—members of the subcommittee as well as others—are known to be deeply worried over the ICBM issue. It could easily result in one of the most momentous debates in recent American history.

The great question that the nation faces is:

- Should the United States use its full productive capacity to turn out *Atlas* in hardened bases to attain ICBM parity with Russia?
- Or, should the United States rely on its overall striking power to deter Russia for the next four years while waiting for the Boeing *Minuteman* to become operational?

Defense Secretary Neil H. McElroy and Gen. Nathan F. Twining, chairman of the Joint Chiefs of Staff, have given the Administration's answer in a series of lengthy appearances before congressional committees in the last few months.

They contend America's overall striking power is great enough and will continue to be great enough to deter Russia even if the Russians use their full capacity to produce ICBM's. This overall power is based primarily on SAC's manned bombers, the nine planned *Atlas* bases, the planned *Polaris* submarine force and the soft IRBM bases in Europe.

McElroy also insists that the defense program was not trimmed to keep it within goals set by President Eisenhower's balanced budget. The Secretary insists that he asked for all the ICBM's he thought the nation needed—and that if he ever thought more were needed he would ask for them.

- **Air alert**—However, McElroy and Twining have said that the threat of Russia's increasing ICBM arsenal may become so acute within a year or so that SAC may have to maintain a 24-hour air alert.

Both also conceded that the United States could approximately match Russia ICBM for ICBM if the *Atlas* program were greatly accelerated.

Convair at present is turning out *Atlas* on only one shift. The company has said it could easily go to two shifts, indicating that production could be doubled.

Twining told the Mahon Subcommittee the principal problems in a speed-up involved training of crews and building hardened bases—not production. However, he said these problems could be overcome if the program were put on a crash basis.

But both Twining and McElroy insisted repeatedly that this course was unnecessary.

- **Increasing danger**—Gen. Thomas S. Power, SAC commander, disagreed. He told the subcommittee America's overall retaliatory power as now programmed over the next four years is deteriorating compared to Russia.

He called for maximum production of *Atlas*, more B-52's and more B-58's and he called for it all faster. He said failure to provide them meant "risking the whole country."

Subcommittee members—already concerned after listening to McElroy—were extremely impressed by Power's statements.

Also, a number of Congressmen have been questioning privately and publicly the validity of claiming the *Polaris* submarine and overseas IRBM bases as plus factors in estimating overall U.S. retaliatory power. They argue the *Polaris* is still unproven and the soft IRBM bases are easy targets for Soviet medium range missiles.

Finally, they stress that deterrent power no matter how great is obviously only successful if it deters.

They argue the United States may be cutting the margin of deterrence too thin for comfort by holding down ICBM production. And that even if the margin isn't too thin, Russia might think it is.

"The psychological factor is extremely important," Mahon said. "It isn't good to be behind."

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PMR Investment to Reach $250 Million In 1962

Extra $75 million probably will be funded in next two years for base construction

by **Robert Mount**

VANDENBERG AFB, CALIF.—Investment in the development of this first operational ballistic missile base of the Strategic Air Command will reach a quarter of a billion dollars by the end of 1962, including construction of at least 26 pads.

The disclosures were made during a recent meeting here where published charges of waste were refuted by Rep. Charles M. Teague of California's Thirteenth District, and Maj. Gen. David Wade, Commander of the First Missile Division at Vandenberg. Assisting with presentation of data to newsmen and local civic leaders were Col. W. E. Leonhard, Deputy Director of Installations, AFBMD, and Col. C. T. Newton, Los Angeles area district engineer, Corps of Army Engineers.

Of chief interest were reports that all overtime salaries to date total only about one percent of total salary expenditures, and that contingency allowances of 10 to 20% over base contract costs have been exceeded only on one Vandenberg contract. In that instance, the contingency costs were about 30%.

The impact of Vandenberg on the area was illustrated by the disclosure that there are now 11,000 persons at the base and the number is rapidly increasing. Those employed at present include some 4000 to 4500 military, 3000 construction and 2800 technical contractor personnel. General Wade told newsmen he sees "no end to the construction program."

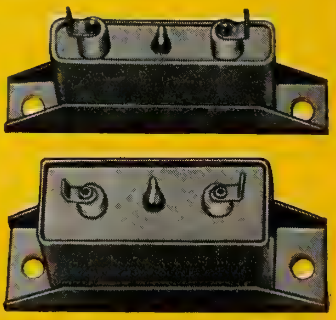
He pointed out that projects in the works or in planning stages include *Thor*, *Atlas*, *Titan*, *Minuteman*, and later programs. Reports distributed to newsmen also listed *Sentry* pads, now under construction for the Air Force and ARPA by the Eleventh Naval District at the Naval Missile Facility, Point Arguello. Works already in the ground are valued at $77.7 million. By the end of the current fiscal year, the total cost will be $173.1 million. Another $75 million probably will be funded in the next two years, according to Col. Newton.

- **Spending breakdown**—Of the $173.1 million total, $113.9 million is for technical facilities, $32.7 million for base support, and $26.5 million for family housing. Of interest economy-wise was the total pre-bid estimate of work now under contract, $109.1 million against the actual bids of $98 million, indicating a paper saving of about $11 million.

Programs discussed included:

Thor—Two wet pads and five dry pads. Total cost $6.2 million. Two static captive firing stands complete, three operational training stands complete, two special purpose stands for *Thor* boosted vehicles complete.

Atlas—Three wet pads and seven dry pads. Total cost $59.7 million. Three launch stands complete, now



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This nonpolarized capacitor is available in a variety of sizes in a capacity range of from 0.05 to 4.0 microfarads at 600 VDC. It is also available in higher voltage ratings. Performance data and operating characteristics are given in Technical Bulletin SL-61 which is supplied upon request.

*Confirmed by qualification test of 1000 hours at 100% rated voltage over ambient temperature range of —55° to +315° C.

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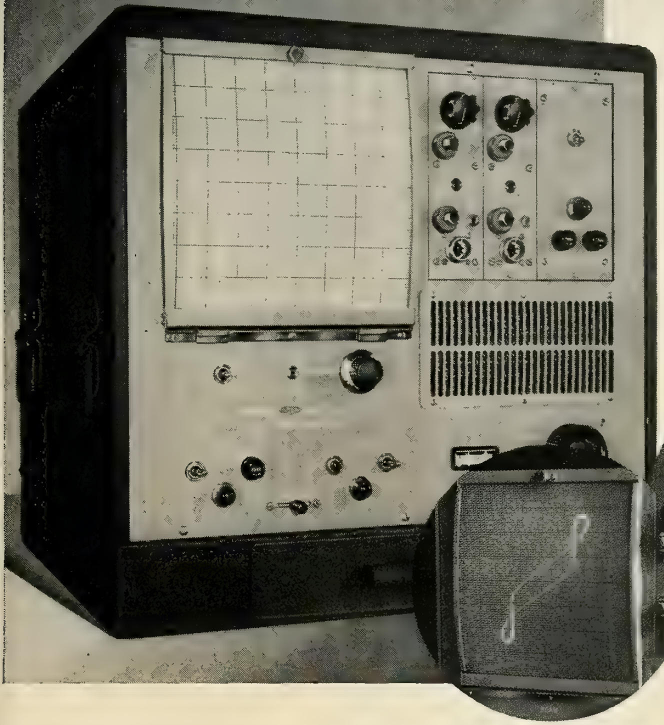

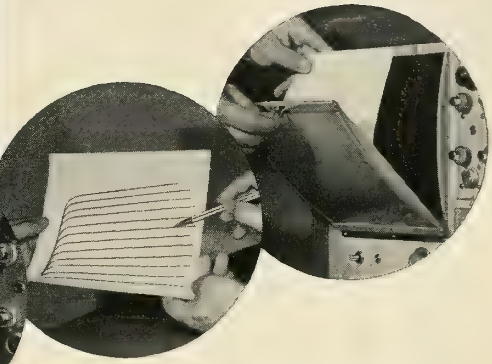

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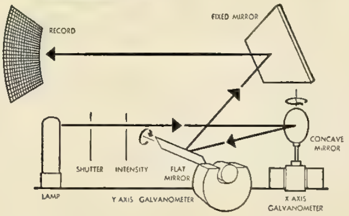
- writing speeds to 2500 in/sec.
- 8" x 8" direct print paper chart
- trace monitoring on phosphorescent screen



X-Y RECORDING never before possible with electro-mechanical instruments can now be done with the new Sanborn Model 670 X-Y Recorder. Direct writing on ultraviolet-sensitive recording paper by a beam deflected by optical galvanometers makes possible the combination of fast writing speed and 130 cps frequency response not found in any other X-Y recorder. Transistor characteristics, acceleration and vibration of mechanical parts and events of similar short duration can be recorded with linearity of *1% of full-scale* and at trace speeds as fast as *2500 inches per second.* Square wave response exhibits no greater than ½% overshoot *at any amplitude;* sensitivities as high as 62.5 uv/inch (depending on preamplifier used).

PLOTS OCCUPY AN 8" x 8" RECORDING AREA and can be previewed or monitored on the instrument's phosphorescent screen. An Axis Record switch to print X and Y axes on the record, and a Beam Intensity Control to assure maximum trace clarity, are among the front panel controls provided. An 8" x 8" sheet of the ultraviolet-sensitive chart paper (stored in drawer at base of cabinet) is easily placed on the back of the hinged screen. Brief post exposure in normal room light is the only developing process.

OPTIONAL INTERCHANGEABLE PREAMPLIFIERS for each axis presently include the Model 850-1300B DC Coupling and Model 850-1200 Phase Sensitive Demodulator; a Carrier Preamplifier, High Gain Preamplifier and a time base generator are now in development. Driver Amplifiers are compact, fully transistorized plug-in units with single-ended input and output. Galvanometers are low resistance, low voltage units of rugged, enclosed construction; sensitivity and damping are independent of coil temperature. Accessible, unitized circuitry also extends to the power supplies—a front-panel plug-in for both preamplifiers and a second supply for both driver amplifiers. A built-in blower provides constant, forced filtered air cooling. The Recorder can be rack mounted in 15¾" of panel space, or housed in its own 20" x 20" x 21¼" optional portable cabinet.

Ask your local Sanborn Sales-Engineering Representative for complete information on the Model 670 X-Y Recorder, or write the Industrial Division in Waltham, Mass.

SANBORN COMPANY

INDUSTRIAL DIVISION
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being checked out to be ready July 1. Three launch stands to be completed soon, technical equipment installations begun. Four launch stands being designed.

Titan—Two soft launch and two hard launch pads. Total program cost $28.3 million. Two soft launch silos and support facilities under construction. Two additional training silos—believed however not for operational use and probably incomplete—planned.

Research and development facilities program, cost $19.8 million, includes: 1. Tracking and telemetry station, $2.6 million under construction; 2. Launch facility No. 1 at Point Arguello—two launch stands, operations bldg. & utilities costing $6 million, an ARPA project (listed in report as Project *Sentry*); 3. Launch facility No. 2 at Vandenberg—three launch stands and service buildings, one block house, complex service building, vehicle storage building, power, utilities and roads. Cost $7.5 million. [Although this project was not identified, it might be for *Minuteman*, which was mentioned by General Wade. Design, scheduled to start this month, would appear to fit the *Minuteman* schedule. Instrumentation and range safety system cost $3 million, for which construction of major units is virtually complete.]

AEC is Recovering Valuable Cerium 144

WASHINGTON—The Atomic Energy Commission has announced that it is now producing, on a routine basis, nuclear heat sources for use with small thermoelectric generators. (Partial breakthroughs have been indicated recently by several manufacturers in development of this type of generator, which will be used in satellites and future spacecraft to operate equipment requiring low power, long life, and high reliability.)

At its Oak Ridge, Tenn., Laboratory, the AEC is separating several different radioactive materials from what otherwise would be waste products of nuclear reactors.

One is Cerium 144, which is preferred over deadly Polonium 210.

Last January, the White House exhibited a five-pound device called Snap III. Heat from radioactive polonium stimulated a flow of electricity in thermocouples. Although it had a capacity of five watts, this early device had two serious faults: Polonium 210 is an extremely poisonous substance and its half-life is only 140 days.

Despite short life, the polonium generator was said to be able to produce as much electricity in 280 days as 1450 pounds of the best conventional batteries. The AEC also said the polonium was welded into a rupture-proof capsule that made the device completely safe to handle.

The commission conceded, however, that Cerium 144 would be a better material. Cerium's half-life is 285 days, and it can be capsuled in an insoluble ceramic form that enhances its safety. The AEC in safety tests has fired welded capsules of cerium against granite without breaking them.

Cerium 144 and other materials are being separated from radioactive waste at AEC's new $2.2 million fission products pilot plant.

The commission said operations "currently are directed toward large-scale concentration" of cerium as a source of "auxiliary electric power for space missiles." The commission is offering radioactive materials from the Oak Ridge plant for peacetime applications at prices about 10% of those formerly in effect.

NASA Reports Successful 5-Stage Sounding Rocket

WASHINGTON—Using off-the-shelf components, the National Aeronautics and Space Administration has developed a five-stage solid-fuel sounding rocket capable of boosting 25 pounds to 525 nautical miles and 100 pounds to 300 nautical miles.

The first-stage motor of the vehicle is an *Honest John* JATO unit M6. The second- and third-stage motors are *Nike* missile boosters, JATO unit X216A2. The fourth-stage rocket motor is a *Recruit*, JATO unit XM19, and the fifth-stage is a JATO unit T55.

A recent paper by Andrew G. Swanson of NASA's Langley Research Center states that several successful operational firings of the new rocket have been made at Wallops Island.

The rocket was launched at an 80° elevation angle with a 49-pound payload and reached a measured apogee of 409.8 nautical miles.

A higher altitude was not attained, according to Swanson, because deviations from the flight path due to wind and thrust misalignments caused the flight path to be slightly lower than nominal value.

The nominal stage impact points for the rocket in a no-wind trajectory would be three miles for the first stage, 5 miles for the second, 60 miles for the third, 200 miles for the fourth, and 500 miles for the fifth.

Velocity of the vehicles was 13,150 fps at fifth-stage burnout and axial accelerations with the 49-pound payload were from 70g to 120g.

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more about the missile week

Operational capability of *Snark* again was checked out successfully April 7 with combat troops performing the launch from Cape Canaveral. Missile made programmed flight to Ascension Island in about eight hours—covering 5,000 miles at 700 mph.

Contractors undertaking research involving advancement of the state-of-the-art are assuming a calculated risk, the Armed Services Board of Contract Appeals has ruled. Failure to come up with a breakthrough can mean they have failed to fulfill the contract. ASBCA made this finding in holding that Aerosonic Instrument Corp. had defaulted on an AF contract to design a portable tester. Aerosonic was unable to meet weight specifications set by the AF.

The Commerce Department's Office of Export Supply has placed Raytheon Mfg. Co. on 12 months probation. Action stems from an investigation of export of television microwave link equipment and parts to Pye Telecommunications Ltd., Cambridge, England, and subsequent trans-shipment of some of the goods to "unauthorized" destinations.

Boron hydride authority Dr. Hermann I. Schlesinger of the University of Chicago has won the American Chemical Society's 1959 Priestly Medal.

Summer school: Yale's Dynamical Astronomy four-week course opens July 6. Registration deadline is April 30. A 10-day Army R&D-sponsored missile and rocket technology institute starts July 26 at the University of Connecticut.

On April 25, the Roswell, N.M., Museum and Art Center is dedicating its new Rocket and Space wing to rocket pioneer Dr. Robert H. Goddard.

General Electric is selling its plastics plant at Taunton, Mass., and the equipment and business of its Decatur, Ill., operation to Haveg Industries, Inc., of Wilmington, Del. Transaction means GE is withdrawing from the custom molded plastics field.

Direct conversion of nuclear energy into electricity with plasma thermocouple has been achieved by AEC in container the size of a frozen orange juice can. Unit produced by SNAP (Systems of Nuclear Auxiliary Power) program is improvement on earlier SNAP III. It could be unlimited power source for spacecraft. Output of 3.8 volts was generated by inserting uranium-enriched rod in vaporized cesium and bombarding entire unit with neutrons in a reactor. AEC also has unveiled a Martin-designed SNAP-powered radio station (W8NPC, 29.06 mc). Generator uses Plutonium 210 as did SNAP III, but is lighter and 5-6½% more efficient.

"Substantial" number more *Thor-Able* tests are likely despite first nose cone recovery on 12th shot, which went 5,000 miles April 8. Miniaturized cone was made of reinforced ceramic-AVCOite.

A contract of unspecified amount has been awarded Sylvania's Electronic Systems division by the Rome, N.Y., Air Development Center to study methods of defensively classifying and tracking enemy ICBM's.

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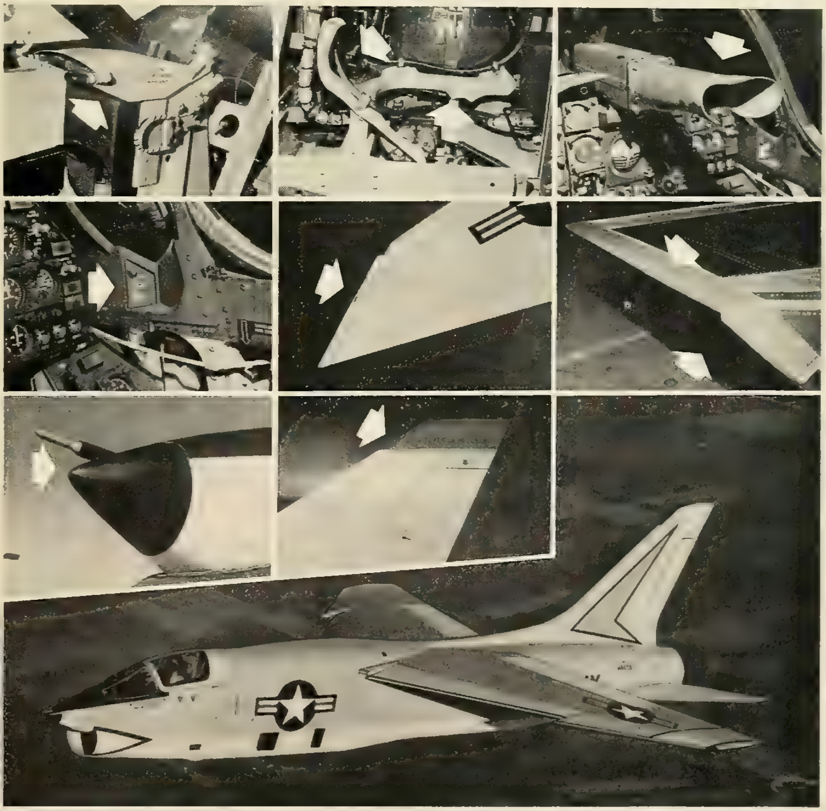

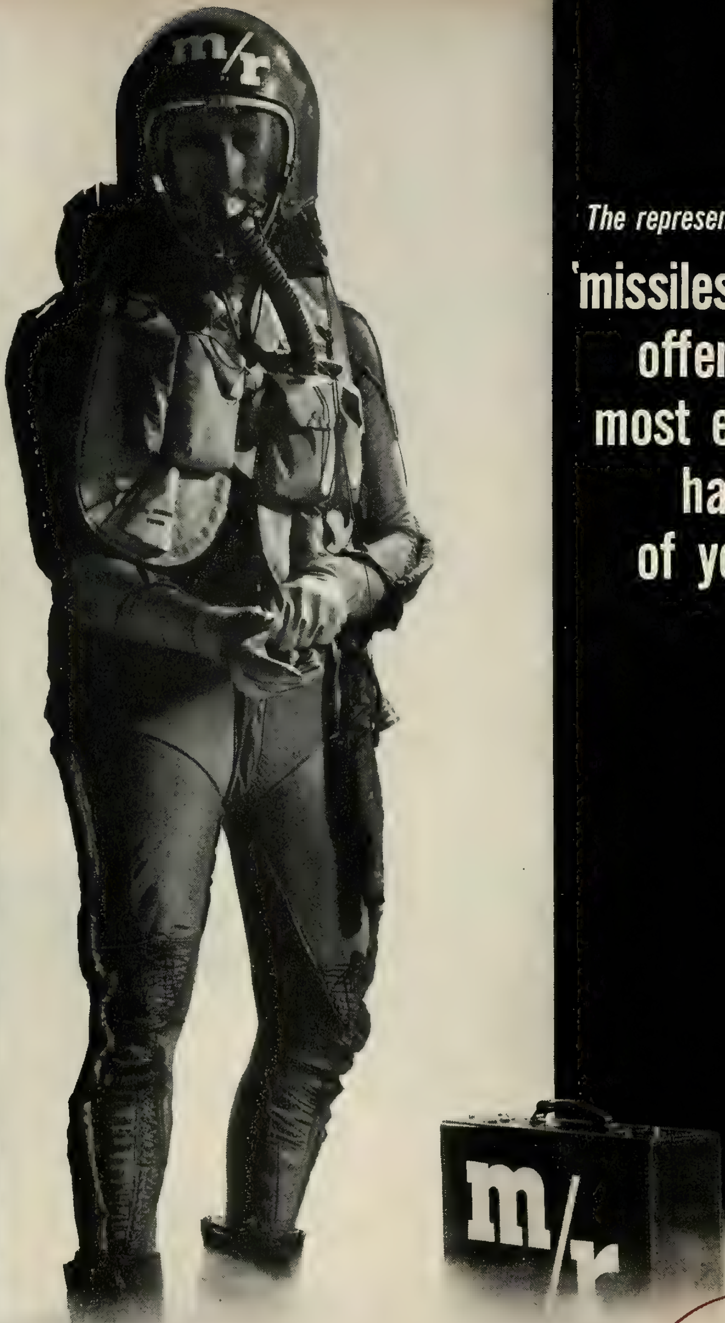

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(Continued from page 24)

countered by upper atmosphere physicists who study (1) the normal ionosphere, (2) the ionosphere disturbed by ultraviolet radiation from solar flares which gives occasional radio blackouts, and (3) the ionosphere disturbed by the incidence of a large flux of charged particles from the sun, for example by low-energy cosmic rays.

The fundamental atomic processes which enter, such as ionization, recombination, attachment and detachment of electrons are basically the same as for the normal ionosphere (See Table 2). The difference in the atomic burst case is mainly due to the fact that the source function occurs very suddenly and then disappears, and that the removal processes of electrons follow thereafter.

Because of the extremely high electron densities encountered, it is quite permissible to neglect the normally existing electron densities, and this simplifies the problem to some extent.

Table 1 collects the important and pertinent data about the concentration of nitrogen and oxygen molecules, oxygen atoms, and of electrons in the upper atmosphere. From these data we can draw some immediate conclusions concerning the fate of the electrons. Table 2 defines some atomic processes which can change the electron density and gives their rate constants.

Below 100 km, we can see immediately that the electrons must have been produced by ionization of oxygen and nitrogen molecules. But only a small percentage of these has been destroyed, most of the oxygen molecules for example are still left intact. Hence there will be two competing processes which remove electrons: (1) A fast process of recombination with molecules. (2) Attachment of the electron to an oxygen molecule; this does not really remove it permanently but, so to speak, stores it and makes it ineffective as far as radio propagation effects are concerned.

At 65 km, however, and at altitudes below this level, attachment begins to predominate over recombination and we are therefore faced with the problem of electrons surviving for longer periods of time. From the attached condition they can be released either by a collisional detachment or by photodetachment when they are struck by sunlight.

It is conceivable therefore that electrons could be stored overnight and then released by the sun. However, since there is no further source of supply at the time they will of course quickly recombine.

We can easily show that *dissociative recombination* removes electrons very rapidly at all altitudes up to about 150 km. But at the very highest altitudes there are not enough molecules left for this process since most of the ionization came from the more abundant oxygen atoms. This depletion of molecules then means that *radiative recombinations* are the only means for removing particles and these proceed at a very slow rate. Therefore high electron densities may persist at altitudes of 200 km for some considerable time.

This slow recombination rate at 200 km explains why we observe an ionosphere at night when the sun's ultraviolet radiation is absent and no further ionization is produced.

- **Countermeasures**—This suggests a possible countermeasure to the high electron densities, namely the release of molecules by artificial means, for example by containers carried up into the high atmosphere with small rockets. These molecules will quickly scavenge or sweep up the free electrons.

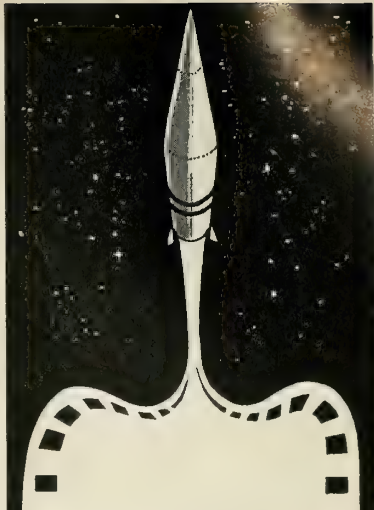
We have made some estimates on the possibility of neutralizing the high electron density by the release of nitric oxide. Unfortunately large quantities are necessary. Ideally one would like a catalyst which speeds up recombination without being used up. Here is a field where additional research might be very fruitful.

In the meantime we must examine how we can circumvent the high altitude electron clouds by electronic means.

If complete ionization at 100 km were possible, leading to about 6 x 10^{12} electrons per cm^3, then serious difficulties could arise; but at low altitudes most of the electrons will be removed quickly by dissociative recombination and by attachment.

At higher altitudes the electron densities could be 10^9 to 10^{10} per cm^3, i.e. 1000 to perhaps as much as 10,000 times higher than the normal electron densities.

But their effects, even if they were to persist for long times, will be serious only for low-frequency communications and radar gear. The frequencies affected will be in the range of 100 to 1000 megacycles; at much higher frequencies there should be little interference with radar defense against missiles.



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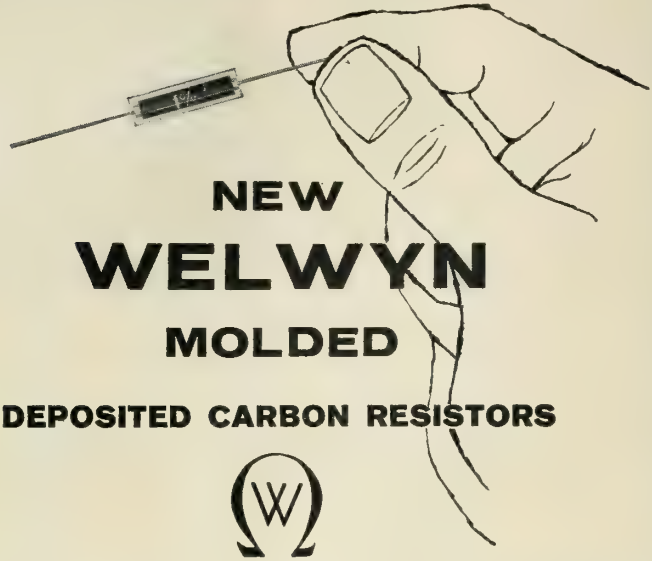

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This molded insulation has an effective resistance in the order of 10^{13} ohms. Its inherent thermal conductivity is approximately ten times that of air, resulting in substantially improved load life under conditions involving excessive or high wattage dissipation. Similarly, Type N resistors may be soldered as close to the insulation as desired without fear of melting or deforming the cover.

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Welwyn Type N carbon resistors meet the requirements specified by MIL-R-10509B, and are available in all values, ranging from 10 ohms through 1 megohm. For complete data and specifications write to Welwyn International, Inc., 3355 Edgecliff Terrace, Cleveland 11, Ohio.

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contract awards

NASA

WASHINGTON—The civilian space agency announced it would buy liquid hydrogen for rockets from the **Linde Co., Div. of Union Carbide Corp.**, for the next five years. Although no guaranteed amounts were given in the contract, it could total more than $1,000,000 annually.

Linde agreed to finance expansion of a plant at Torrance, Calif., to supply NASA's requirements.

Consolidated Systems Corp., Monrovia, Calif., subsidiary of **Consolidated Electrodynamics Corp.**, received a $348,700 NASA contract for an automatic data-recording and monitoring system to acquire and process data from rocket motors being tested by JPL at Edwards AFB.

Other awards:

ARMY

$6,372,000—**Western Electric Co., Inc.**, for R&D on *Nike-Zeus* program (Bell Telephone Laboratories, Inc., will carry out work).

$5,044,080—**Firestone Tire & Rubber Co.**, for guided missile artillery.

$2,687,725—**Western Electric Co., Inc.**, for *Nike* spare parts and components (18 contracts).

$2,645,000—**North American Aviation, Inc., Rocketdyne Div.**, for rocket engines.

$2,078,000—**The Martin Co.**, for continuation of R&D on *Pershing.*

$984,000—**Avco Manufacturing Corp.**, for research in re-entry physics.

$657,296—**Raytheon Manufacturing Co.**, for electronic assemblies for *Hawk.*

AIR FORCE

$4,000,000—**Goodyear Aircraft Corp.**, for *Atlas* ground support and launching equipment (add-on orders from **Convair**).

$2,000,000—**Marquardt Aircraft Co.**, for radar signal simulators.

$1,324,172—**International Business Machines Corp.**, for SAGE data processing equipment.

$752,000—**IBM**, for study for SAC Subsystem 438L.

$491,174—**Hewlett-Packard Co.**, Palo Alto, Calif., for various electronic items.

$300,000—**Bogue Electric of Canada, Ltd.**, Ottawa, for power supplies for SAGE data processing equipment (subcontract from **Burroughs Corp.**).

$211,275—**Ampex Corp.**, for tape recorder/reproducer, components and spare parts.

$116,630—**Boeing Airplane Co., Pilotless Aircraft Div.**, for technical data for *Bomarc* components (two contracts).

(**Sylvania Electric Products, Inc.**, received a contract from the Rome Air Development Center for ICBM detection study. Amount was not disclosed.)

(**Avion Div., ACF Industries, Inc.**, received an ARDC contract to study detection of infrared radiations from satellite vehicles. Amount was not disclosed.)

NAVY

(**RCA** received a contract totaling several million dollars for development of new communications systems for submarine-based *Polaris* missiles. Exact amount was not disclosed. Work will last several years and involve a number of subcontractors.)

$1,000,000—**American Potash & Chemical Corp.**, for ammonium perchlorate (letter of intent).

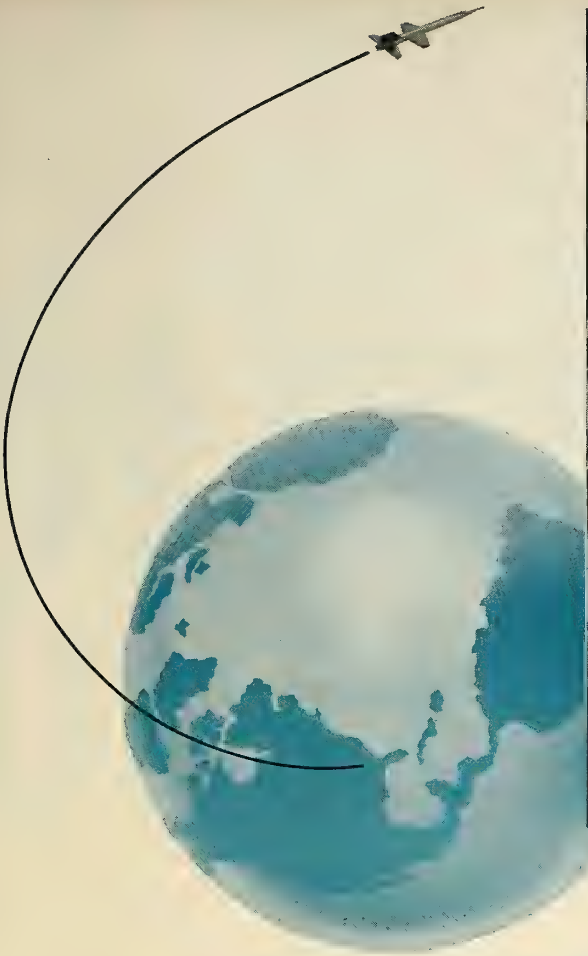
$391,938—**New Mexico State College**, for research on the upper atmosphere.

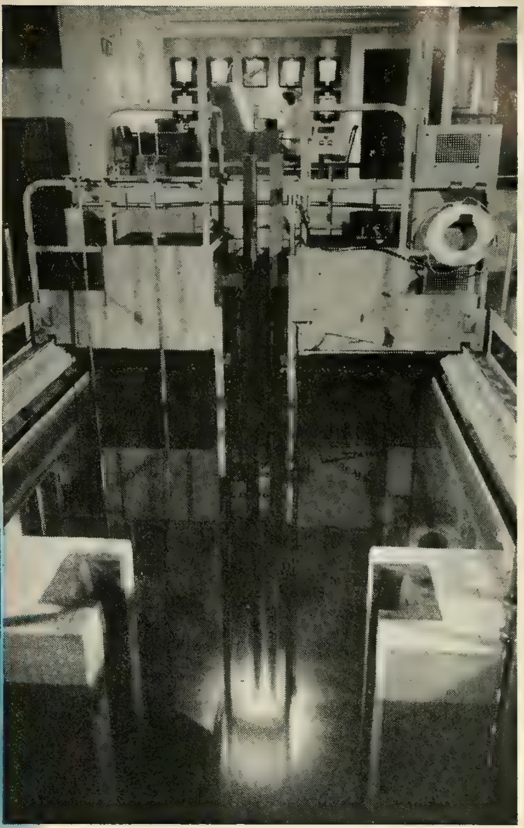
$209,373—**Cooper Development Corp.**, Monrovia, Calif., for research on measurement of solar flare phenomena.

$172,121—**Technical Appliance Corp.**, Sherburne, N.Y., for Minitrack satellite tracking system.

$106,639—**Raytheon Manufacturing Co.**, for 66 man-months of engineering services to support *Sparrow III*, and associated equipment.

$103,591—**Barnes Engineering Co.**, Stamford, Conn., for design, test and production of three models of an infrared free air thermometer system.





Ford Nuclear Reactor at the University of Michigan

COMMUNICATION SYSTEMS

that resist nuclear radiation

Positive and reliable communications are the lifelines of new strategic weapons, hypersonic aircraft, satellites, and air defense. Resistance to nuclear radiation damage is an additional prerequisite for some of these advanced weapon systems.

The Bendix Systems Division, using the Ford Nuclear Reactor at the nearby University of Michigan, is developing radiation-resistant Mission and Traffic Control equipment. This work is being conducted by Bendix as a contractor to the Air Force. The objective is an M&TC subsystem providing extreme reliability under severe environmental conditions and over long operating periods.

Hypersonic aircraft and re-entry vehicles require that communications overcome the attenuation of surrounding ionized air. Bendix is carrying out propagation investigations and experimenting with designing special digital and voice communication systems. This work is under way at the Systems Division, Radio Division, and Pacific Division of the Bendix Aviation Corporation.

Positive communications also require resistance to jamming. Advanced research at the Bendix Systems Division has evolved techniques that combine jamming resistance and security of transmission.

Advanced communications know-how is being applied to additional programs for which the Systems Division has system management and engineering responsibility—such as the Navy EAGLE System and the Air Force AN/AMQ-15 Weather Reconnaissance System—and is applicable to many others.

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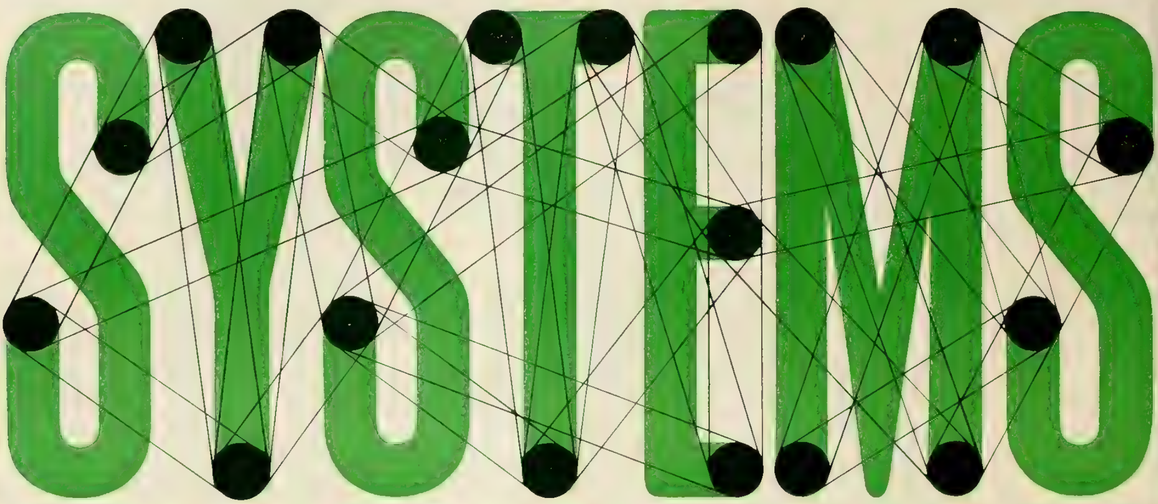

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RADAR ENGINEER to analyze ultimate limits and present techniques and to develop new concepts providing topographical sensors for advanced airborne and space systems. Design airborne radar pulse, microwave and deflection circuitry. Analyze doppler radar systems to determine theoretical accuracy and performance limitations. Experience with transistor circuits or radar test equipment is highly desirable.

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people

The National Aeronautics and Space Administration has named 13 government, university and industrial scientists to two working groups which will correlate research propects with future satellite and space probe payloads.

One group, charged with the problem of orbiting astronomical observatories, will be headed by **Dr. Nancy Roman** of NASA, and includes **Dr. J. E. Kupperian,** NASA; **Dr. A. Code,** University of Wisconsin; **Dr. L. Goldberg,** University of Michigan; **Dr. A. B. Meinel,** Association of Universities for Research in Astronomy, Inc.; **J. E. Milligan,** NASA; **Dr. L. Spitzer,** Princeton University, and **Dr. F. L. Whipple,** Smithsonian Astrophysical Observatory.

This group will explore X-ray, ultra violet and infrared regions of the electromagnetic spectrum.

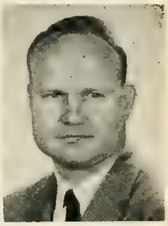
The other group, working on the problem of orbiting satellite ionospheric beacons, will be headed by **J. C. Seddon** of NASA, and includes **Dr. C. G. Little,** National Bureau of Standards; **Dr. W. J. Ross,** Pennsylvania State University; **Dr. G. W. Swenson,** University of Illinois, and **Dr. O. G. Villard,** Stanford University.

This group will study the distribution of electrically-charged particles and electron concentration in the ionosphere, and will work to put multi-frequency radio beacons into a 200 to 500 mile orbit.

THIEL

Dr. Adolph K. Thiel has been appointed Program Director for Space Missions, Space Technology Laboratories, Inc. Formerly director of the *Thor* Program Office, Thiel, 44, will direct STL programs including fabrication, assembly and flight test responsibilities associated with space projects.

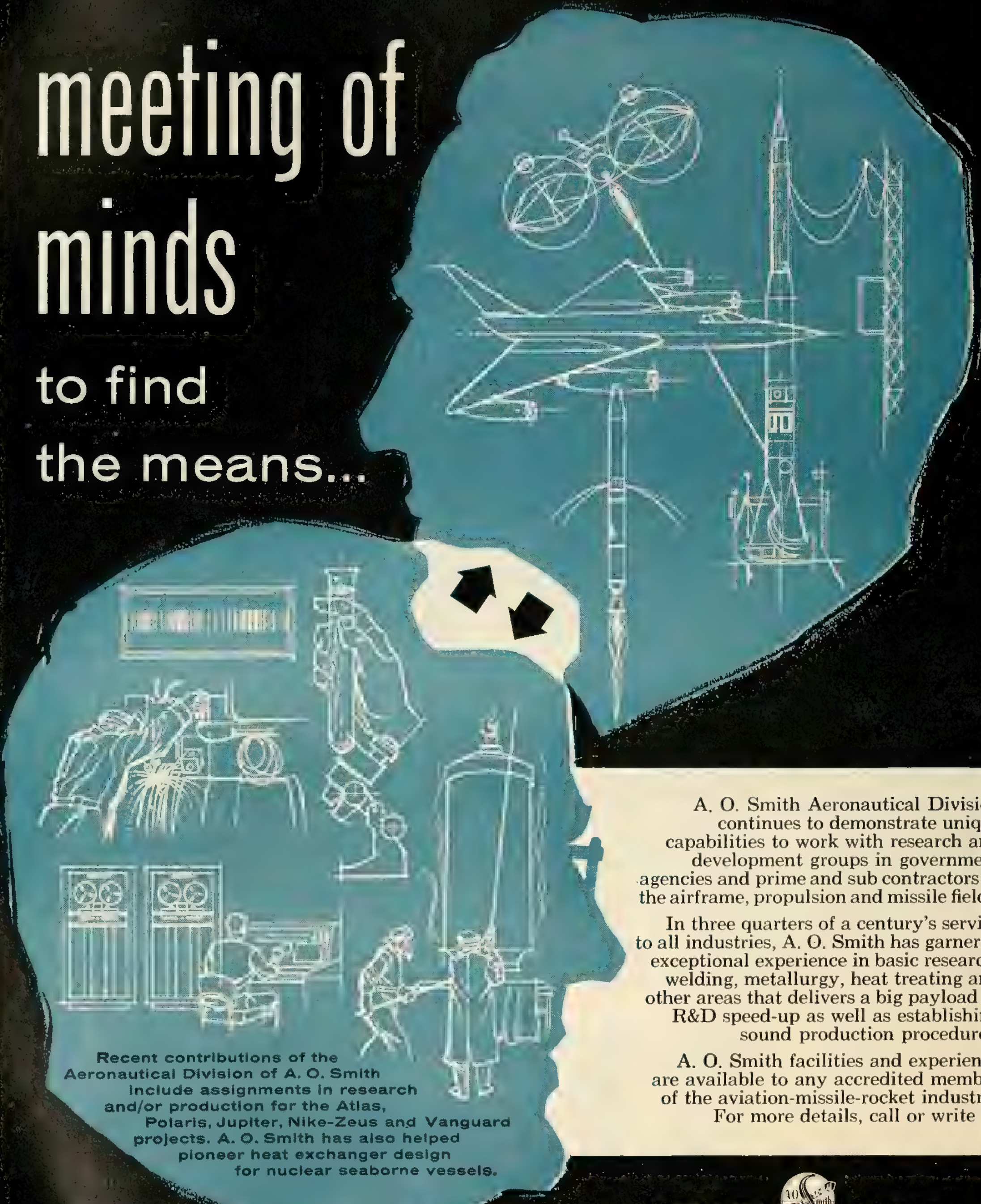
Appointment of **D. Brainerd Holmes** as Manager, BMEWS, has been announced by Missiles and Surface Radar Division, Radio Corp. of America. He will coordinate design, development and production phases of the Ballistic Missile Early Warning System.


MURPHY

Robert W. Bratt is chief of Douglas Aircraft Company's new $10-million Aerophysics Laboratory and **Dr. James S. Murphy** has been named assistant chief. The new center will be utilized in high-speed research on missile development as well as commercial and military aircraft.

meeting of minds

to find the means...



Recent contributions of the Aeronautical Division of A. O. Smith include assignments in research and/or production for the Atlas, Polaris, Jupiter, Nike-Zeus and Vanguard projects. A. O. Smith has also helped pioneer heat exchanger design for nuclear seaborne vessels.

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propulsion engineering

Vast increases in I_{sp} into ranges recently considered impractical, will soon be revealed by a fairly new propellant company that has been working with aluminized perchlorates. The company won't say whether these perchlorates are involved with the radically new fuels it has developed. The propellants will be solids.

Long-duration solids for Navy use will also be announced by the same firm. Additives will at least triple and quadruple present burning time, a company official says.

Metal particles 1000 times smaller than any previously produced are paving the way for wide use of metal as additives to solid propellants. National Research Corporation is considering putting its process for making extremely fine aluminum powder into commercial operation. So far, NRC has produced aluminum, iron and nickel particles a millionth of an inch in diameter. The chemical industry wants the iron and nickel powders, as well as aluminum, for catalysts in commercial operations.

Super insulation race is on in earnest. National Research Corporation has revealed a lightweight cryogenic insulating powder it says is 15 times better than any powder announced so far. Until now, the record has been held by Linde Company with a powder 26 times more effective than vacuum insulation (Propulsion Engineering, April 6). Neither firm will reveal details. However, it's known that both systems involve very fine powders (for point contact to reduce heat flow) in combination with high vacuum. NRC points especially to the newest material's low density—2.2 lb/ft^3—which makes air transportation of LOX, liquid H_2, etc., more practical.

Make-up of NASA's Chemical Energy Processes Research Advisory Committee has been announced. The 14-chemist committee is headed by Astrodyne executive vice president James A. Reid, formerly a Phillips Petroleum research chemist, later director of research, and high official in the national synthetic rubber program. Other members are: E. J. Froehlich, JPL; David Altman, Aeronutronic Systems; John Drake, Marquardt Aircraft; R. J. Thompson, Rocketdyne; A. L. Antonio, Aerojet; Allen R. Deschere, Rohm and Haas Chemical; Prof. Farrington Daniels, University of Wisconsin; B. H. Sage, Caltech; W. H. Avery, Johns Hopkins Applied Physics Lab; Frank Tanczos, Navy BuOrd; C. M. Hudson, Army Ordnance; John Longwell, Esso Research and Engineering; Marc P. Dunnam, Wright Air Development Command. NASA headquarters staffer chosen as permanent secretary is Harold Hipsher.

Zone refining techniques used to purify germanium and silicon for transistors are now applied by a British firm to purifying organic compounds and liquids. L. Light & Co., Colnbrook, has not applied the technique to fuels, but says it works well on compounds structurally similar to some fuels. To purify liquids, Light first freezes them and then zone-melts these solids.

Mine Safety Appliances Company—a parent of Callery Chemical—has developed a device that detects 0.5-10.0 ppm of UDMH in a plant or at a launching site.

New ozone production details are out and confirm that the National Bureau of Standards technique revealed in this column (March 16) actually will greatly reduce cost. High price has kept ozone in the laboratory and out of large-scale missile development. The process—microwave dissociation of oxygen cooled by liquid nitrogen—resulted from studies on trapped free radicals. The Bureau gives credit to R. A. Ruehrwein and J. W. Edwards of Monsanto Chemical, and J. S. Hashman of Callery Chemical, who were industry guest workers in the Bureau's free radical program.

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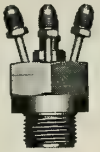

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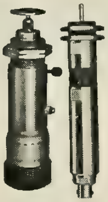

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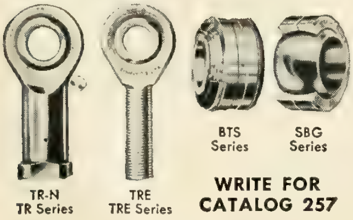

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missile business

by William E. Howard

Moving into the research "gap" in anti-submarine warfare for the Navy are two special task-force-type organizations set up by Lockheed Aircraft and General Dynamics. Both companies will draw on their full resources to tackle the complexities of ASW technology. Lockheed has designated its operations as LAWSO (Lockheed Anti-Submarine Warfare Systems Organization). There is no special name for the General Dynamics program.

LAWSO will function as part of the company's California Division under the overall supervision of Burt C. Monesmith, Lockheed vice-president and divisional manager. Edward M. Davis, former naval officer and chief of Lockheed's advanced ASW design projects for the past nine years, will manage LAWSO. He will have a group of from 12 to 25 specialists who have already put about 18 years and a quarter-million man-hours into investigations in the field.

Lockheed is putting the scientific resources of its four divisions—embracing aircraft, missiles and electronics—at the disposal of LAWSO when specific problems arise. The new unit will be an element of the California division's advanced systems research organization headed by W. H. Statler.

He says LAWSO will make a "complete systems" approach—involving detection, classification, communications, armament, vehicle and logistics support equipment in addition to personnel. Small specialist groups will cover underwater acoustics, nuclear physics, aircraft design and equipment, electronic data processing, electromagnetics, oceanography and related areas.

In the week before LAWSO was announced, Lockheed disclosed that it had acquired control of the Pudget Sound Bridge & Dredging Co. with an eye toward building nuclear-powered ships and providing ground support facilities for missiles and space vehicles. What role this new addition could play in the ASW set up was not specified by the company.

Statler says LAWSO will be seeking balanced systems abilities as a top goal. "Each must function at the optimum level in relation to each of the others." This will entail working with Navy scientific and administrative agencies and with special groups in other companies. Lockheed specialists involved include Vice Admiral A. B. Vosseller, USN (Ret.); and Drs. J. E. Lipp, Lewis Larmore and Leon Aloglu.

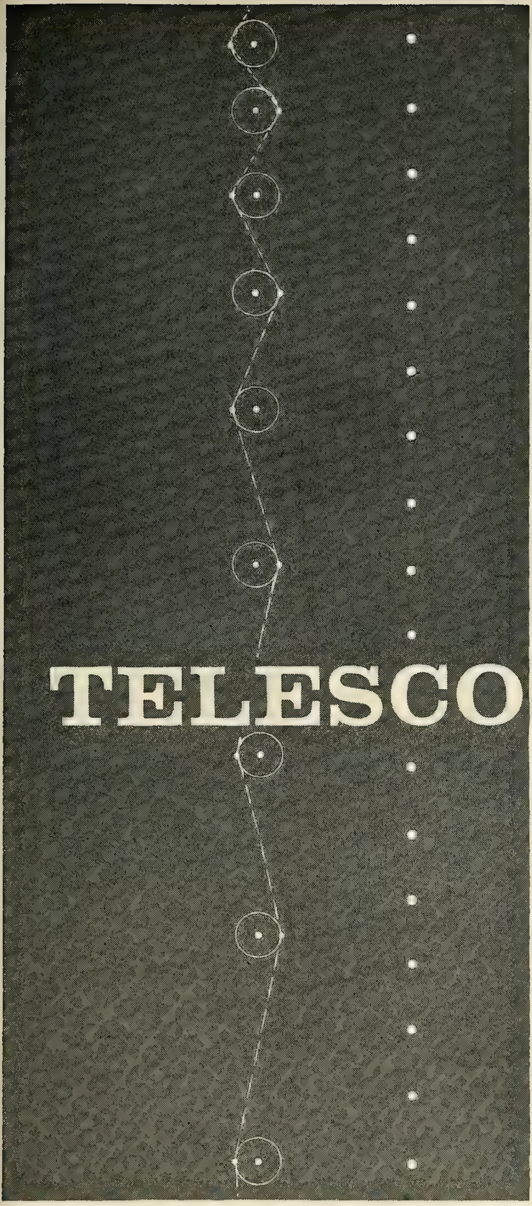
Their studies may involve combining weapons with detection and destruction equipment; extra long-range alarm systems and perhaps manned stations on the ocean bottom for biological and "ocean climate" research. Statler says there will not be any large-scale hirings but a few experts are required in oceanography, acoustics and other areas.

General Dynamics, in a somewhat similar organization, has established a company-wide coordinating committee of 20 to 25 persons headed by Lawrence B. Richardson—engineering senior vice-president. The committee is charged with guiding and directing divisional activity in future ASW planning. It assigns responsibility for action. And individual committee members have department command authority to back up decisions with orders, rather than just requests for action. The coordinator for the committee is James G. Wenzel, vice-president of Convair-San Diego.

G-D has had an ASW program group since 1957. The new set up is designed, says Wenzel, to cover the "whole spectrum" of problems in submarines, missiles, electronics, airplanes, surface craft and communications. He adds, "each of our divisions already has made some outstanding contributions in some part of the spectrum—but not all of it." The committee's job is to tie the program together.

A key tool in the program will be a $250,000 underwater acoustic testing laboratory the company is building at its Stromberg-Carlson Division. G-D funded, this will be the nation's largest indoor unit of its kind.

ENGINEERS–SCIENTISTS



Engineers and Scientists at Republic Aviation—with a turn for dry professional humor—say that they're asked to solve every problem of upper atmosphere and space flight with the factor

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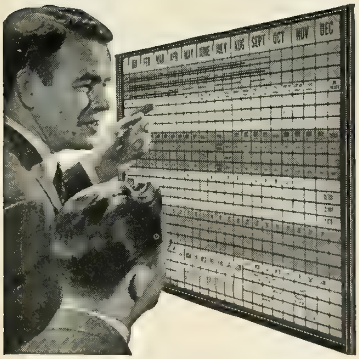

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Aeronautical Training Society, 17th Annual Meeting, Desert Inn, Las Vegas, Apr. 16-17.

Institute of Radio Engineers, 11th Annual Southwestern Conference and Electronics Show, Memorial Auditorium, Dallas, Apr. 16-18.

Third National Conference, Aviation Education, Riverside, Calif., Apr. 17-18.

Institute of Radio Engineers, Spring Technical Conference on Electronic Data Processing, Cincinnati Section, Engineering Society, Bldg., Cincinnati, Apr. 21-22.

Institute of Environmental Engineers, 1959 Annual Meeting, La Salle Hotel, Chicago, Apr. 22-24.

American Society of Mechanical Engineers, First National Metals Engineering Conference, Hotel Sheraton-Ten Eyck, Albany, N.Y., Apr. 29-May 1.

American Rocket Society, Controllable Satellite Conference, Massachusetts Institute of Technology, Cambridge, Apr. 30-May 1.

MAY

Air Force Office Scientific Research/-Chemistry Div. and Electromechanical Society, Symposium on Electrode Processes, Philadelphia, May 3-7.

Institute of Radio Engineers, 11th National Aeronautical Electronics Conference, Dayton, Ohio, May 4-6.

Instrument Society of America, 5th National Instrumentation Flight Test Symposium, Olympic Hotel, Seattle, May 4-8.

International Scientific Radio Union, Spring Meeting, Willard Hotel, Washington, D.C., May 5-7.

1959 Electronic Components Conference, Benjamin Franklin Hotel, Philadelphia, May 6-8.

Institute of Radio Engineers, Seventh Regional Conference and Trade Show, University of New Mexico, Albuquerque, May 6-8.

Armed Forces Day, Observances scheduled throughout week of May 9-17.

Aviation Writers Association, 21st Annual Meeting and News Conference, Washington and Willard Hotel, Washington, D.C., May 10-16.

The Atomic Energy Commission, Technical Information Meeting on Test Reactors, National Reactor Testing Station, Idaho Falls, Idaho, May 13-15.

Society of Aircraft Materials and Processing Engineering—Eastern Div., Spring Meeting, Hotel Statler, New York City, May 15.

Society of Aeronautical Weight Engineers, 18th Annual National Conference, Hotel Henry Grady, Atlanta, May 18-21.

The Society for Experimental Stress Analysis, 1959 National Spring Meeting, Sheraton Park Hotel, Washington, D.C., May 20-22.

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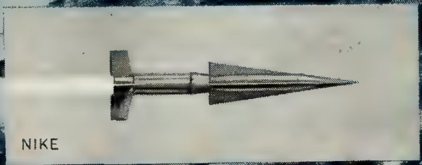
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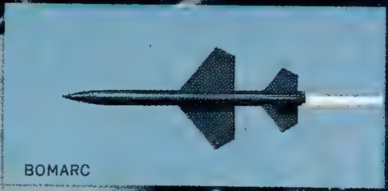
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shows [illegible] square miles of U.S. and Mexico

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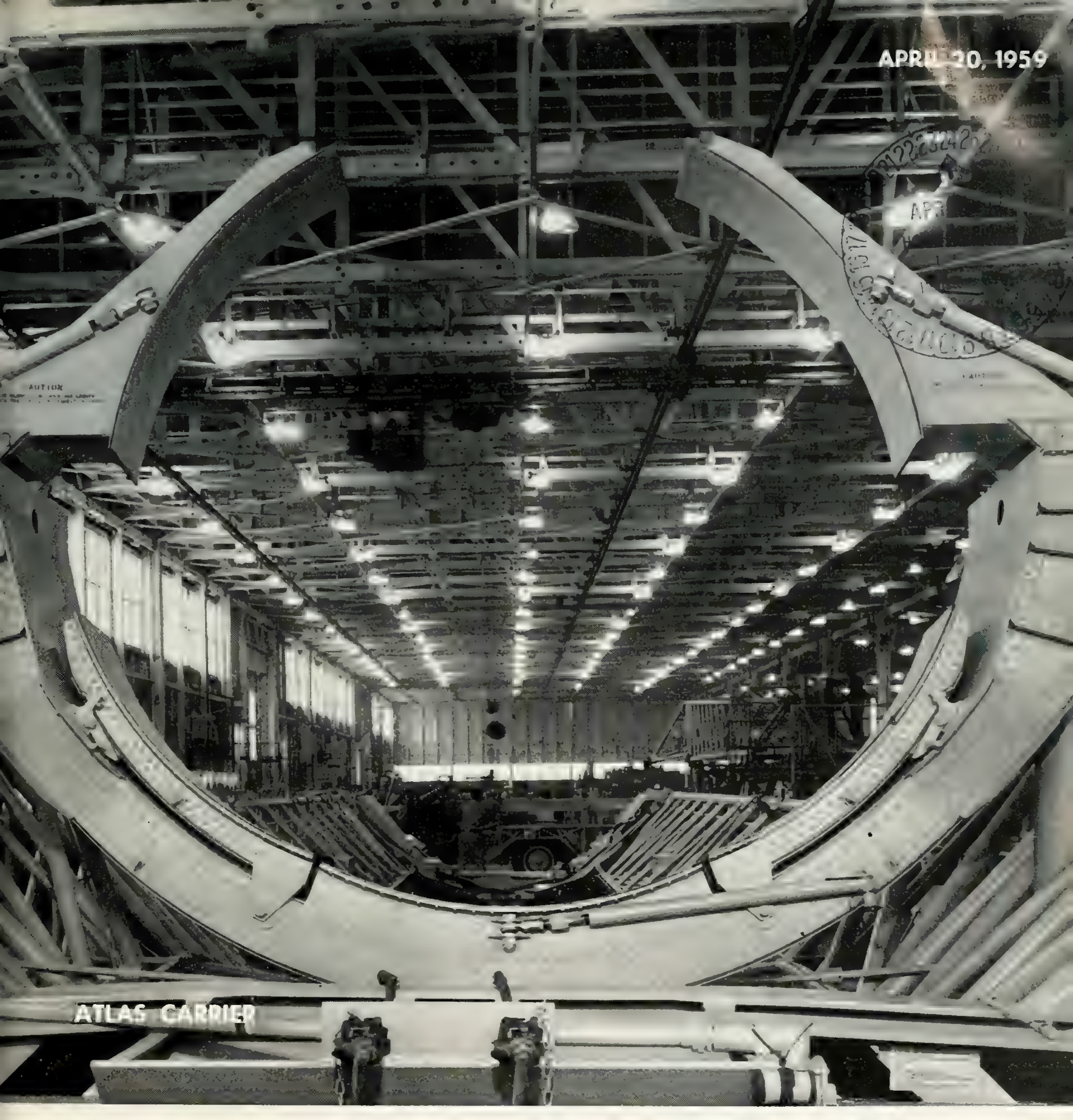

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5	+.8900	−.1988
6	+.8000	−.1088
7	+.9000	−.1188
8	+.0000	−.1198
9	−.0000	−.1108
10	−.0001	−.1118
11	−.0002	−.1119
12	−.0003	−.1110
13	−.0004	−.1111
14	−.0005	
15	−.0006	
16	−.0007	
17	−.0008	
18	−.0009	
19	−.0019	
20	−.0029	
21	−.0039	
22	−.0049	
23	−.0059	
24	−.0069	
25	−.0079	
26	−.0089	
27	−.0099	
28	−.0199	
29	−.0299	
30	−.0399	
31	−.0499	
32	−.0599	
33	−.0699	
34	−.0799	
35	−.0899	
36	−.0999	
37	−.1999	
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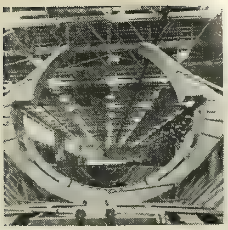
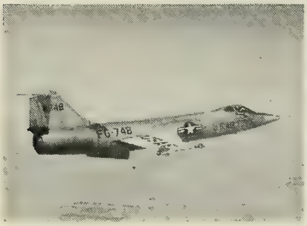


COVER: Goodyear has gone into a new line of support equipment for *Atlas* (p.23)



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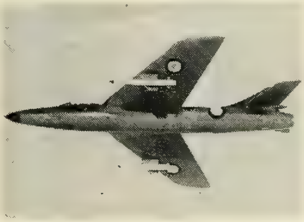
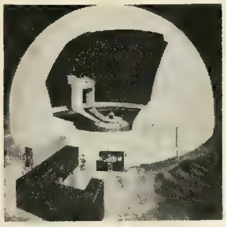


INFRARED seeking *Firestone* by deHavilland is carried on Hawker Hunter in this recently released photograph.



ELABORATE and costly flight training facilities will be a part of GSE when man enters the missile (p. 20)

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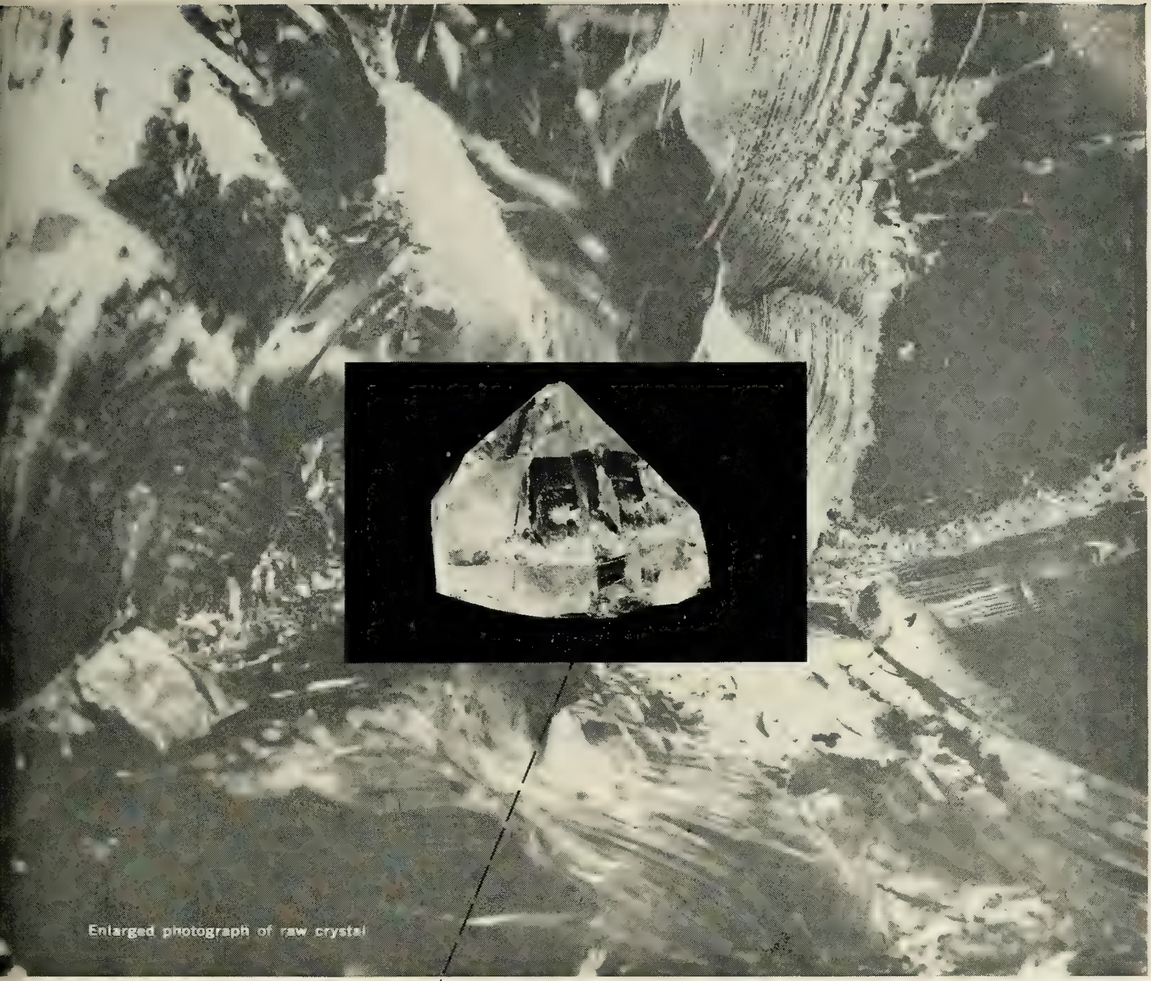

Enlarged photograph of raw crystal

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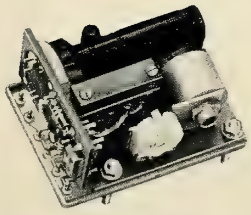

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These unique crystal controlled variable frequency oscillators are only one of many recent advances made by Bulova Electronics. For information on these units, or on how Bulova experience in mastering component and system reliability can help your program, write Department A-1231, today.

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ELECTRONICS DIVISION · WOODSIDE 77, NEW YORK

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Brush militarized recording

ystems are....

READY NOW FOR "2nd GENERATION" SPACE VEHICLES!

When "second generation" space vehicles become operational, the readout of their performance will be monitored by Brush militarized equipment already in existence.

For instance, the 100-Channel Operations Monitor that will record 100 channels of data simultaneously – on a chart 12″ wide! Complex checkouts are simplified.

Or 2- and 6-channel systems (including oscillograph and amplifier)...or the combination Analog and Sequential Recorder.

All equipment complies with Mil. E-16400, Mil. E-4158, Mil. E-4970 and other specifications as required.

For maximum reliability, equipment utilizes fast-response electric writing, proven on critical operational sites such as DEW Line, Jupiter and Thor checkouts.

It will pay to get familiar with this equipment now – before you are confronted with prototype design problems. Brush engineers are available to give you needed details, or write us direct.

brush INSTRUMENTS
DIVISION OF
37TH AND PERKINS CLEVITE CORPORATION CLEVELAND 14, OHIO

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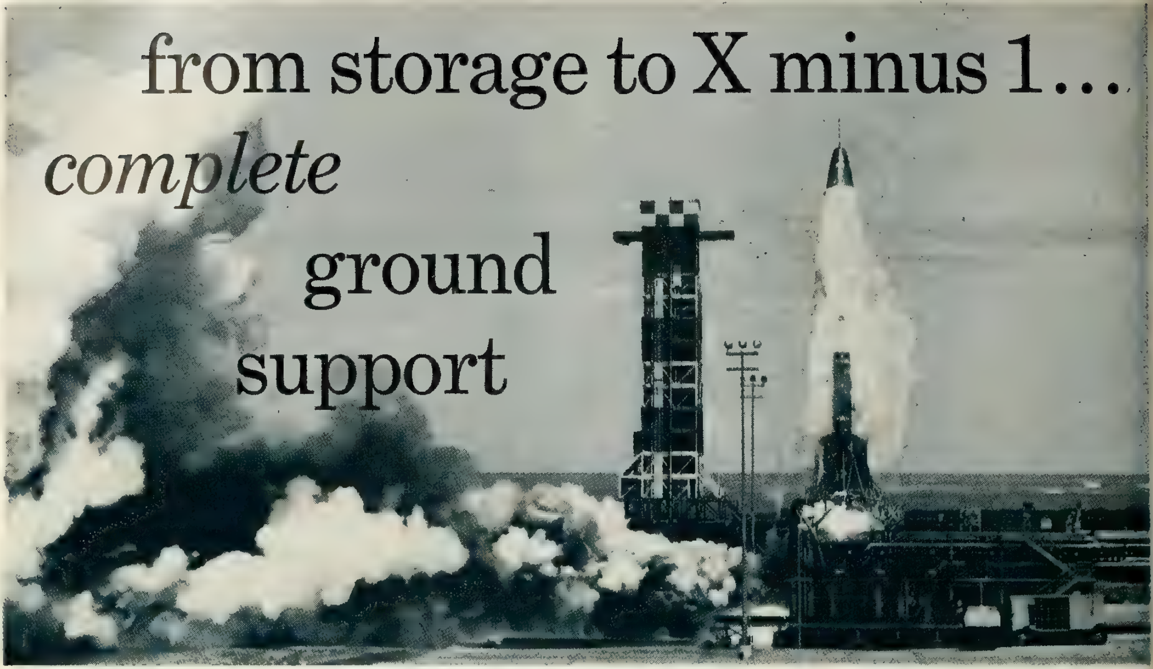


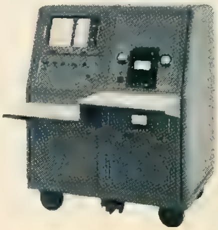
from storage to X minus 1... *complete* ground support

CEC's design capabilities and facilities for developing and producing complete missile ground support equipment is a matter of record. Typical of CEC's ground support equipment are static and dynamic checkout units for fuel systems . . . propellant utilization exerciser systems...and electronic systems for telemetry, inertial guidance, and control checkout. For full information, send for CEC Bulletin 3017-X4.

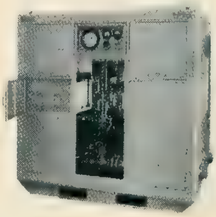
Consolidated Systems CEC

CONSOLIDATED ELECTRODYNAMICS *300 N. Sierra Madre Villa, Pasadena, Calif.*

FOR EMPLOYMENT OPPORTUNITIES WITH THIS PROGRESSIVE COMPANY, WRITE DIRECTOR OF PERSONNEL



Propellant Utilization System Exerciser sequentially generates precise pressures for the fuel and oxidizer channels at 25 preselected points on a scale from zero to maximum, making possible precise checkout.



Pneumatic Checkout System is essentially a go, no-go device that automatically pressurizes and tests missile pneumatic systems during storage and pre-countdown periods. Sensing units detect any malfunction, transmit signals to automatic comparator.

Circle No. 6 on Subscriber Service Card.

We Educate Our Youth—Or Russia Will

U.S. industry has long shared a general concern that the country's annual harvest of scientifically trained college graduates was falling considerably below an essential level and dangerously behind the crop produced by the Soviet Union. But it has not done enough about its concern.

Congress voted a loan program last year to encourage scientific education, but student loan money—long available from other sources—went begging to a large degree. Young people have always been reluctant to step out on their own with a heavy debt over their heads. Individual companies and associations have helped by providing scholarships and making grants to colleges and universities, but the administrative process of awarding these has limited the number who could participate.

Now, with establishment of the National Merit Scholarship Corporation, a means has been established to provide the small or medium-sized company with a centrally organized, low-cost national testing mechanism to help them make the best use of available scholarship funds. And, because NMSC runs the administrative end of the program, from providing the academic testing to selection of the winners, companies which provide the funds are assured that 100% of their contribution goes to scholarship winners to defray education expenses.

The National Merit Scholarship Corporation was launched in 1955 with grants of $20.5 million from the Ford Foundation and the Carnegie Corporation. Since 1952 the Ford Foundation had been studying the possibilities of a nationwide scholarship program financed by private sources. One conclusion they came up with couldn't have been too startling—that most of the more able students who dropped formal education after high school gave lack of sufficient funds as a reason.

There were other conclusions: with the U.S. population increasing at the rate of three million a year and with the Cold War continuing to demand more and more of our industrial capacity, the competition for skilled help has become much sharper; that the lean crop of depression babies due to reach productive manhood (age 25-34) in the mid-1960's will be 700,000 fewer than today; that one-third of the top quarter students graduating from high school named science or engineering as their first choice for a continued education; that actually one-half of this one-third did not get to college at all.

Industry, which had not done too much before the advent of NMSC to ease the problem, in the last three or four years has come forward with a substantial beginning which reflects not only concern but acceptance of at least a share of the responsibility for solving the whole scientific education problem. This participation has gone up annually until some $12 million in scholarship aid has now been committed and 2300 of the nation's most able students are continuing an education which might otherwise not have been possible. In addition, an increasing number of companies have been awarding scholarships to children of employees on the basis of their performance in the Merit competition.

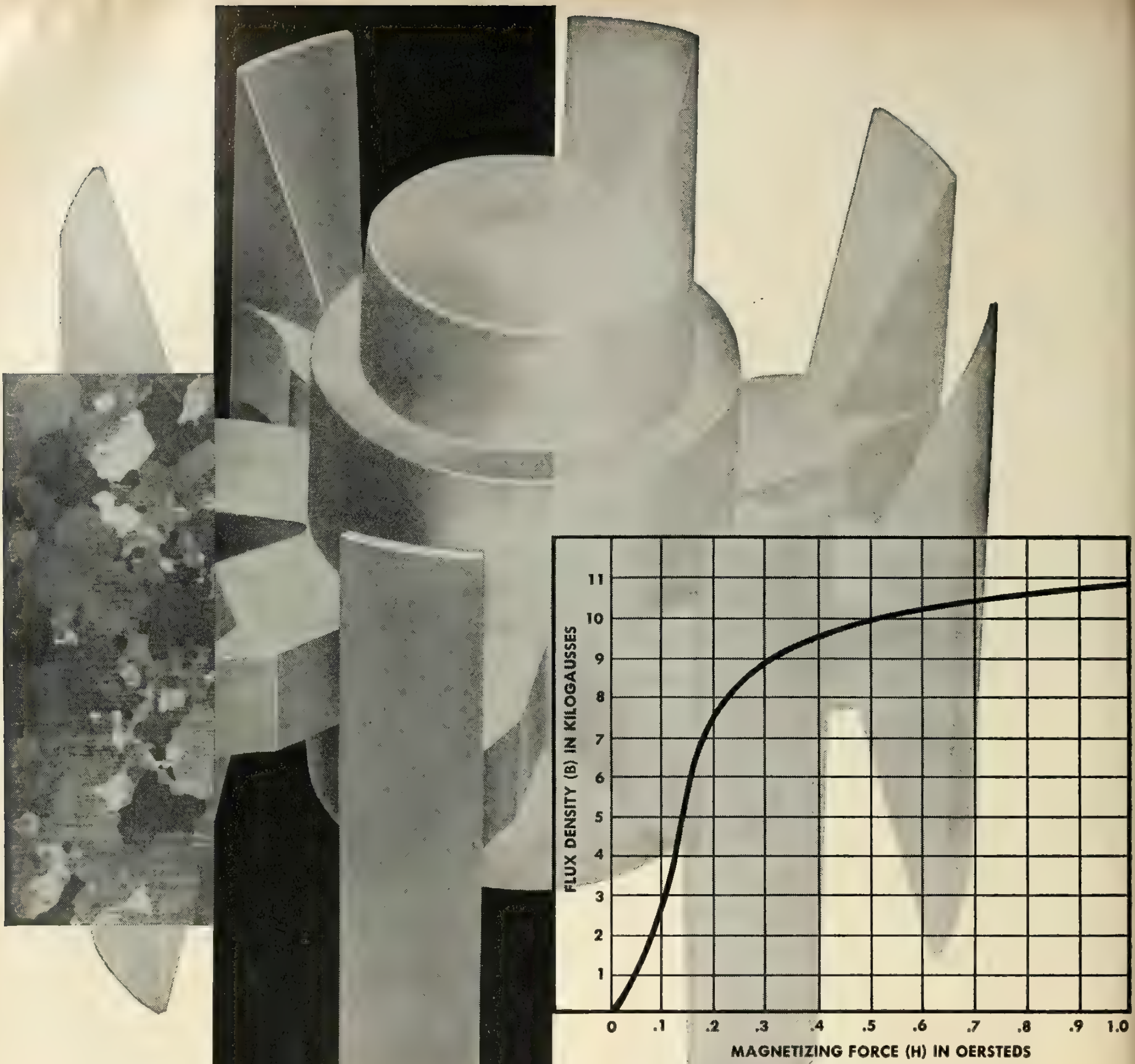
The number of companies actually participating in NMSC, to a large or small extent of the $12 million total, is 80.

We should like to see it stepped up to 800 and $120 million—ten fold—because we face a formidable antagonist who has stepped up his not ten but 20-fold. Russia's planning is long-range in view and deadly in intent. There, education right through the graduate and professional level is free and is available, according to official USSR announcement, "to everyone having the capacity to use it productively."

Today's engineering student is tomorrow's builder, inventor, genius. The challenge as well as the problem is clear. Industry, which has so very much at stake, must recognize that this is among the greatest of its responsibilities. Let's say that $12 million is a fair start, but only fair. And why only 80 companies out of America's thousands?

As another recently expressed it, we believe: "The rule is absolute, the race which does not value trained intelligence is doomed . . . tomorrow science will have moved forward yet another step, and there will be no appeal from the judgment which will be pronounced on the educated."

Clarke Newlon



B-H curve for average precision cast Hipernik.

Investment casting eliminates costly machining of this Hipernik magnetic alloy hysteresis clutch.

Westinghouse Hipernik Casting

. . . cuts costs, retains magnetic properties

The field of electronics has created special metal problems. The Westinghouse Metals Plant has accepted and solved some of these problems.

Cast Hipernik® is particularly adaptable to the requirements of missile control systems. Other applications in the electronic control and instrumentation fields are transformer cores, pole pieces, solenoids, torque motors, magnetic clutches and many special magnetic applications.

The Westinghouse Metals Plant may be able to cut your costs by eliminating unnecessary machining, yet delivering to you a completely finished component ready for assembly. This modern metals plant can furnish strip, sheet and bar stock in other magnetic and high temperature alloys. Write to: Westinghouse Metals Plant, Blairsville, Pennsylvania. Our latest bulletin on Hipernik will be sent to you by return mail. J-05005

YOU CAN BE SURE...IF IT'S Westinghouse

WATCH "WESTINGHOUSE LUCILLE BALL-DESI ARNAZ SHOWS" CBS-TV MONDAYS

Circle No. 7 on Subscriber Service Card.

washington countdown

IN THE PENTAGON

Research and Engineering Director Herbert York and his new R&E office are taking another long look at the *Nike-Zeus* AICBM program. Two of the principal reasons: The results of Project *Argus* and mounting pressure to find a defense against missiles in the face of Russia's increasing ICBM stockpile.

• • •

The Navy expects to have a fleet of five commissioned *Polaris* submarines by the end of next year. Three of the Nuclear subs will be ready to be placed on station by next summer—the earliest that Lockheed's *Polaris* is expected by some officials to be operational.

• • •

The Navy is engaged in one of its hottest behind-the-scenes fights in years. The issue: Navy Undersecretary William Franke's organization study recommending abolishment of restricted line officer billets and creation of a Naval Technical Corps. Opponents charge this means industry would soon find itself dealing strictly with non-technical line officers at the top of the Navy's big technical bureaus. Insiders also charge the real reason for the proposal is the Navy has fewer and fewer top-drawer sea commands to go around.

• • •

The Pentagon is pressing ahead with $6 million-a-year program of research projects aimed at developing low-altitude "flying saucers" based on the principal of creating a ground air cushion. They would range in size from a dozen to 1,000 feet or more in diameter. One huge model would skim the world's oceans at possibly hundreds of miles an hour and serve as a mobile seaborne landing field or rocket-launching platform. DOD will review all projects next month at a conference at Princeton University.

ON CAPITOL HILL

A new public battle appears certain over the on-again off-again U.S. program aimed at developing a nuclear-powered airplane. The Joint Congressional Atomic Research Subcommittee will hold its first public hearings on the controversial program later this month. In the past, subcommittee members have repeatedly called for more action on the program and administration officials have countered with public replies. But all hearings on the program have been secret.

• • •

Space exploration may pay off in more than glory for the first man to leave the Earth in a space craft. Rep. Victor L. Anfuso (D-N.Y.) has introduced a bill that would award the first American spaceman a tax-free $100,000 prize. The bill would not require the winner to collect in person.

• • •

The House Military Operations Subcommittee will issue a report on its investigation of management of the Air Force missile program without holding further hearings. The report is expected to be released in about a month.

AT NASA

NASA project people are split on whether the new family of *Scout* research vehicles is really needed. One proposal is a three-stage *Vanguard* which could be fired later this year while *Scout* probably would take at least 12 to 18 months development time before production. Systems manager selection for *Scout* is still undecided with NASA laying plans for fabrication "in house" at Langley. NASA's *Vanguard* proponents say modified *Vanguard* could do the job just as well as *Scout* and perhaps at less cost.

AROUND TOWN

Top U.S. space experts will meet in Washington June 29 for a two-day symposium on space research. The symposium is being sponsored by the National Academy of Sciences, the American Physical Society and NASA. It will end the academy's annual meeting which opens June 27. The academy also will hold symposiums on oceanography, the atmosphere and some of the still secret results of project *Argus*.

Jupiter and Redstone

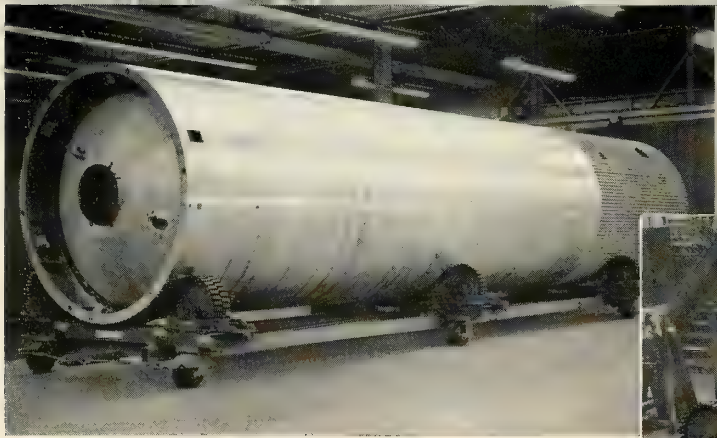
with Aronson

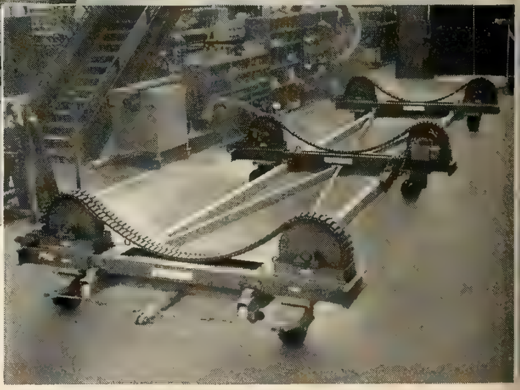
TRAC-TRED* TURNING ROLLS

*T. M. REG. U. S. PAT. OFF. PAT. NO. 2,669,364

The U. S. Army Ordnance Michigan Missile Plant, operated by the Missile Division of Chrysler Corporation had problems concerning the handling of the Redstone and Jupiter missiles with their thin-walled skin (aluminum) without damage, such as wrinkling, marring or indenting. Also how to position the missile when being X-Rayed and having certain assemblies added as well as moving the large skin from place to place.

Their solution to these problems was Aronson Rubber Trac-Treds installed on specially built dollies: two (2) Idler double Trac-Treds with rubber treds and staggered to give constant contact with the skin and so positioned as to permit 90 degrees of the skin's surface to be nestled and supported by the treds. These Idlers are placed at either ends of the dolly. The Single-Rubber Trac-Tred Driver Unit, also giving 90 degrees of surface support, is located in the middle of the dolly providing the turning power. The Trac-Tred Driver unit is 110 volt to enable the complete unit to be moved to and worked on anywhere in the large plant.





For Steady, Positive, Precision Rotation of THIN-WALLED VESSELS use ARONSON TRAC-TRED TURNING ROLLS

Quality POSITIONERS by **Aronson MACHINE COMPANY**

ARCADE, NEW YORK

WELDING POSITIONERS • TANK TURNING ROLLS • TURNTABLES

Circle No. 8 on Subscriber Service Card.

BRUNSWICK "SHOOTS" THE RADOME RANGE TO 1200° F

Brunswick makes a new breach in the thermal barrier with newly developed non-metallic materials that boost the temperature tolerance of radomes and nose cones to 1000-1200°F for limited exposure periods – almost twice the previous limit. This new advance in Brunswick's Strickland 'B' Process of filament winding opens a new chapter in aircraft and missile designing.

New "SBP" filament winding results in the highest strength-to-weight ratios ever obtained in radomes and nose cones with significant weight savings over conventional structures. With unmatched electrical uniformity, Brunswick builds them to meet the tightest tolerances for dielectric constants and compound configurations. Brunswick offers full electronic testing facilities.

Brunswick radomes and nose cones now slice skyward on such supersonic aircraft as the advanced Convair F-106; on such missiles as the Boeing Bomarc and Lockheed Q5. For details on Brunswick's leadership in research, development and testing, write: The Brunswick-Balke-Collender Company, Defense Products Division, 1700 Messler St., Muskegon, Mich.

BRUNSWICK

MAKES YOUR IDEAS *WORK*

Circle No. 9 on Subscriber Service Card.

The low-down on low-level missions

Let them hide that target in a deep gorge . . . surround it with jagged peaks . . . shroud it with fog. A plane with an Autonetics monopulse radar system—like Republic's F-105—can find it at will . . . day or night, rain or snow.

Lightweight, compact NASARR is the only system in production that is equally effective for air search, automatic tracking, air-to-ground slant ranging, and terrain avoidance—from sea level to stratosphere. Accurate ground mapping rounds out NASARR's uncanny versatility.

Autonetics builds NASARR for the AN/ASG-19 armament control system—standard equipment for advanced versions of the F-105. Like all Autonetics guidance and control systems, NASARR does its delicate work *reliably* under extremes of speed, altitude, and temperature.

NASARR is one example of the type of system that is resulting from Autonetics' decade of development in monopulse radar.

Autonetics A DIVISION OF NORTH AMERICAN AVIATION, INC., DOWNEY, CALIF.
REGIONAL OFFICES: WASHINGTON, D.C. AND DAYTON, OHIO

INERTIAL NAVIGATION / ARMAMENT CONTROL / FLIGHT CONTROL / COMPUTERS AND DATA PROCESSING

Circle No. 10 on Subscriber Service Card.

industry countdown

STRUCTURES

Decision on air launched ballistic missile contractor is now expected on or before June 1. Why the rush and high priority? Oliver M. Gale, special assistant to Defense Secretary McElroy, says by 1963 SAC bombers equipped with ALBMS will be America's "major instrument" of retaliation against Russia. Gale indicates all other weapons systems will be secondary to ALBM, including *Polaris.*

• • •

Highly secret Project *Slam*—an advanced weapons system for the Air Force—is being developed by Chance Vought Aircraft. No one is saying officially what the project is about. But *Slam* is thought to mean "Space Launched Air Missile."

• • •

France's Nord Aviation is pushing production of "tens of thousands" of *S-10* and *S-11* anti-tank missiles for NATO countries. U.S. is the main customer.

• • •

Expanding French research organization S.E.P.R. is exploring cooperative tie-up with German companies. Recently allied with Italy's Bombrini-Parodi-Delfino, S.E.P.R. is developer of liquid and solid fueled rocket engines. Has operational a fighter plane, the Dassault Mirage III A, equipped with both jet and rocket engines.

• • •

First two artillery battalions to man the Martin *Lacrosse* surface-to-surface guided missile will be activated by June 25 at Ft. Sill, Okla. Six more battalions are programmed.

PROPULSION

Rocketdyne is test-firing a 400,000-pound thrust liquid propelled engine, which it says is largest of type in this country. Slight modification is expected to boost thrust to more than one-half million pounds. Engine appears to be scaled-down version of one million pound engine being developed for NASA—indicating single chamber of 1,000,000-lb. class is not yet in advanced hardware stage.

• • •

Goal of $250,000 Aerojet-General feasibility study is one-million pound thrust solid fueled rocket motor which would quadruple present capability. Aerojet believes study will pay off in providing know-how for building 10-15 million pound thrust engines.

ELECTRONICS

Future replacement for transistors in some uses is Naval Ordnance Laboratory's new "solion"—which carries electrical charge by ions in solution. Already applied in five elemental types for different circuit arrangements, unit is reported to be long-lived, stable, light-weight and simple. It requires 1/100 to 1/1000 the power needed for a transistor.

• • •

Promising results are reported by the National Bureau of Standards in laboratory investigation of two new test devices. They are: a modified plasma jet, operating at up to 8000° C, to provide excitation for spectrographic analysis of complex alloys (tests on stainless steel samples were accurate to within 2% coefficient of variation) and a stroboscopic vibration analyzer. This instrument determines aircraft and missile structural vibration characteristics for submicroscopic movement. Device uses transducer or vibration pickoffs for oscilloscopic display of amplitude and phase relations of complex structures.

• • •

For master planning, overall design and development of improved AIRCOM (Air Force Communications Complex) ITT is setting up a new unit—ITT Communications Systems Inc. at Paramus, N.J.

ASTROPHYSICS

Data for AF space programs is being gathered in series of flights to 115,000 ft. by 5¼ million cu. ft. helium balloons launched at Vernalis, Calif., by Cambridge Research Center's Research and Development Command. Instrumentation package is parachuted back to earth while balloon rises until it is shattered by expansion and cold in upper atmosphere.

SPACE MEDICINE

To determine space radiation effects upon a human, Los Alamos Scientific Laboratory has devised a mannequin called REMAB (Radiation-equivalent Man, Absorption). Transparent and containing skeleton, lungs and solution comparable to human tissue, REMAB is fitted with dosimeters to measure radiation exposure.

How To Specify Ground Communications For a Missile Base

First, consider the supplier's experience and reputation. DuKane Corporation, pioneer in electronic communication systems, has installed ground communication equipment on such bases as White Sands, Patrick AFB, and Fort Churchill . . . *Second*, get help from an expert. DuKane's engineers are ready to help you. They've had wide experience in all phases of communications, including giving direct help to architects and consulting engineers in designing systems to meet any combination of needs . . . *Third*, consider equipment and flexibility. Of all the manufacturers of voice communication equipment, only DuKane makes a truly complete selection: intercom, public address, paging, background music, private automatic telephone, wireless paging for key personnel, emergency and evacuation systems, and hospital communication systems—in any combination to form an integrated system of any size, a few stations to hundreds.

For missile base ground communications, come to the experts . . . Write or wire DuKane Corporation, Dept. MR-1, St. Charles, Illinois. If you specify electronic equipment, ask also for DuKane's chart of electronic equipment symbols.

DUKANE CORPORATION
St. Charles, Illinois

Job-engineered sound installations . . . Flexifone intercom systems . . . Private automatic telephone systems . . . Hospita communications systems . . . Ionovac hi-fi tweeters and ultrasonic generators . . . Sound slidefilm projectors for education and industry . . . Electronic production facilities for industry and for defense.

Circle No. 11 on Subscriber Service Card.

APRIL 20, 1959—VOL. 5, NO. 16

missiles and rockets

MAGAZINE OF WORLD ASTRONAUTICS

With government reconsidering fast tax write-offs, will—

1959 Be 'Boost' or 'Bust' Year for Space Research?

by William E. Howard

WASHINGTON—Importance to national security of winning the technological race into space is forcing the government to reconsider its pre-*Sputnik* decision to end fast tax write-offs for industry this year.

Administration officials are moving to extend rapid amortization provisions for another four years and to relax the regulations to include contractors for NASA and possibly the Federal Aviation Agency, M/R has learned.

Behind the move is a dawning realization that industry's lack of ready cash to plough back into basic research may be slowing down and injuring the nation's missile/space effort.

Industry leaders say most companies are "not sufficiently healthy moneywise" today. As a result, plans for needed facilities and research are going begging on the shelf. They blame much of their predicament on:

- A sharp curtailment in tax write-offs rammed through Congress in August, 1957, by Sen. Harry F. Byrd (D-Va.). This law expires Dec. 31.
- Renegotiation Board grabbing of legitimate "extra" profits on incentive-type contracts.

"Time is money," one Air Force contractor said, "The brains to solve R&D problems are available. It's a question of using them. The more we spend, the quicker we'll get the answers."

• **Cut to trickle**—If industry were allowed by the contract Renegotiation Board to retain even 3% or 5% for research it would make a "tremendous difference," many spokesmen say. The Pentagon is sponsoring a change in the Renegotiation Act for precisely this purpose. More important to industry, however, is the ability to conserve larger amounts of capital for research through rapid amortization of expensive plants and equipment.

Since the Byrd law went into effect, only a trickle of fast tax write-off certificates have been issued by the Office of Civil and Defense Mobilization. The total since June, 1958—about $100 million. Of this amount, approximately $80 million has been certified for missile/space R&D (see accompanying table).

And of the $80 million, companies are being permitted to write off an average of 65% over five years, instead of the customary 20 to 40 years. So the actual amount made available through this device over the past 10 months amounts in current yearly deferment to about $10 million—for the entire industry. Previous deferments run to approximately $35 million a year. These will be used up by 1962.

• **NASA pushing**—Although OCDM originated the legislation now being circulated through executive agencies, it is understood NASA is the prime mover.

Details of the proposed measure have not been divulged. But officials indicate that it would be a wide departure from the Byrd law, embracing all contracts involved with air-space aspects of national defense. This could mean a considerable liberalization of present regulations which restrict OCDM certificates to new research and development for the DOD and AEC.

• **Government paradox**—A possibility exists that this measure may never be introduced in Congress, if it meets with overriding objections from Internal Revenue and the Budget Bureau. Both these agencies view fast write-offs as a "loss" in revenue.

(Continued on page 53)

OCDM RAPID AMORTIZATION CERTIFICATES

June, 1958-April, 1959

COMPANY	PURPOSE	NO. CERTIFICATES	TOTAL AMOUNT CERTIFIED	% ALLOWED
AEROJET-GENERAL	Rocket propulsion	4	$2,012,000	60
AVCO MFG.	Ballistic missiles	1	438,000	60
BOEING AIRPLANE	Space vehicles & missiles R&D	4	3,221,000	60-65
CALLERY CHEMICAL	High-energy fuels	1	3,832,000	65
COLUMBIA BROADCASTING SYSTEM	Communications	1	1,102,000	25
CONVAIR	Missiles	5	1,810,000	60-65
FAIRCHILD	Missile engines	1	750,000	60
GENERAL ELECTRIC	Missiles guidance	3	20,509,000	50-65
HERCULES POWDER	Solid fuels	1	4,608,000	65
HUGHES AIRCRAFT	Electronic systems	3	1,738,000	65
LOCKHEED AIRCRAFT	Missile fabrication	11	3,139,000	60-65
MARQUARDT AIRCRAFT	Missile engines	1	375,000	75
MARTIN CO.	Missile R&D	10	3,322,000	60-65
OLIN MATHIESON	Propulsion systems	2	908,000	50-60
MOTOROLA	Electronics	3	773,000	65
POTTER AERONAUTICAL	Missile components	1	3,313,000	65
PRATT & WHITNEY	Rocket engines	1	8,200,000	70
REPUBLIC AVIATION	Missiles	1	5,570,000	65
ALBERT RIDINGER	Rocket chambers	1	1,188,000	65
TEXAS INSTRUMENTS	Electronic	2	5,230,000	40
THIOKOL CHEMICAL	Engine, fuel R&D	2	774,000	65-80
UNION CARBIDE	Missile parts	1	3,472,000	50
WESTERN ELECTRIC	Electronic systems	7	2,043,000	50-65

What will be needed in GSE—

When Man Enters the Missile

by Hal Gettings

WASHINGTON—Putting men into space vehicles will change the entire concept of ground support equipment, demanding much bigger handling and support vehicles, a far higher degree of safety and reliability, additional tracking facilities and landing and recovery systems—all at considerable cost.

This is the opinion of Ben F. Werner, ground systems branch manager of Boeing Airplane Co., who contends that the ground system has not received early and proper emphasis because its importance has been dwarfed by the vehicle itself.

Werner believes there is urgent need now for a balanced effort in all elements of the space program—especially in ground support—to meet the new and fascinating problems in design, management and operation raised by the requirements of a manned operational system.

The accompanying graph prepared by Werner shows, in terms of engineering manpower, the magnitude of the ground support effort for a typical manned space system. Costs of the total system and of the ground support elements can be expected to show a similar relationship.

WERNER

Werner points out that some existing support equipment and procedures can and should be used in future manned systems. However, some requirements will demand entirely new approaches. They include:

1. The use of man as an integrated part of the system;
2. Consideration of his safety and well-being;
3. Increase of boost energy imposed by the added weight, and
4. The fact that the vehicle will return to earth.

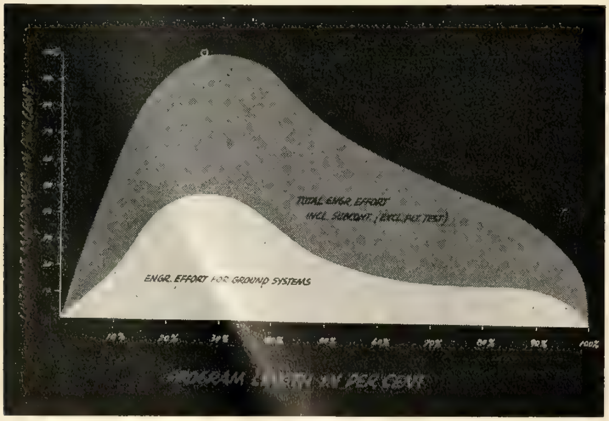
Each ground support job must be thought of as one with many other interrelated functions of an operational system. Attention must be given to research and development in new areas and to extending the state of the art in others.

• **Propulsion**—A larger propulsion system means larger handling and transportation vehicles, dollies, and cranes. Hoists will be required for vertical lifts in excess of 100,000 pounds. Likewise, transport equipment will be required to carry these loads, some of which may be as long as 200 feet, and designed for critical shock and bending stresses. A larger propulsion system means a bigger gantry, possibly up to 300 feet high, with up to 1500 tons of steel required.

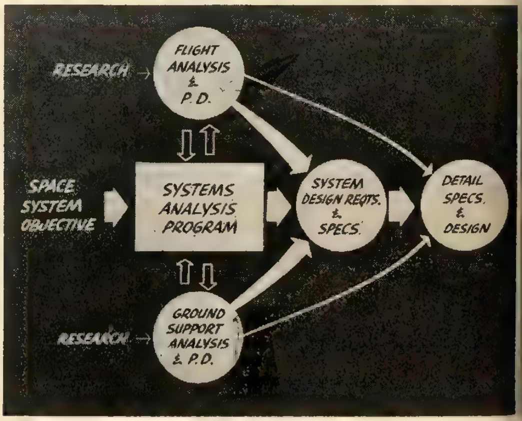
One new design proposed by Werner involves a multilaunch operational system wherein the vehicle and its propulsion system are assembled horizontally on a strongback in an assembly and test shop and then rolled to the launch area for erection by 3500-psi hydraulic actuators. For such a system the explosive propellants conceivably may be manufactured at the base rather than transferred cross-country.

Propulsion systems based on exotic fuels such as liquid hydrogen and fluorine and, ultimately, nuclear fuels will present new ground support problems. Recoverable boost stages may be used for certain operational systems, and recovery and recycle maintenance of recoverable boosters will introduce a whole new order of ground support

Bigger percentage of engineering effort on GSE . . .



GSE on par with flight development . . .



jobs and procedures.

• **Safety**—A higher degree of safety will be necessary at the launch site. Heretofore the launch area was cleared and control personnel safely hidden in a blockhouse well away from the site. But in the manned system a man will be sitting right on top of the powderkeg. Fueling procedures and last-minute servicing techniques must be developed to insure the greatest possible safety during this critical phase.

The question then arises as to when in the countdown the man should be put in the vehicle. Is a system provided for quick exit if something goes wrong during final countdown? What part will the man play as part of the control loop in the countdown sequence?

The reaction time of a manned system will inherently tend to be somewhat longer than that of the unmanned system. Means must be devised to shorten this period. Methods and mechanisms to put the man aboard are in their infancy, but Werner believes that rapid means to get the pilot to his station may be accomplished by employing elevators, tramways, or hydraulic lifts. There is no question that countdown time is at a premium with a man aboard. It's possible that certain countdown checks and functions may be delegated to the man—a possible simplification of the unmanned system.

• **Increased reliability**—The requirement of increased reliability is a tough one. Previously, costs and simplicity could be weighed against certain abort and failure rates; now reliability must be considered from the standpoint of man's safety at the launch site. The use of qualified proven equipment must be emphasized—both for the vehicle itself and for the ground support elements. Even though the man himself may increase the overall mission reliability, the test and prelaunch checkout job does not obviate the need for test equipment reliability, Werner said.

• **Escape system**—Providing an escape system imposes further requirements on the ground checkout function. If an escape system is to be effective, it must be capable of being exercised at any instant. During the flight phases the pilot has time to evaluate the need for using the system; but during launch and initial boost he may be incapable of recognizing the existence of trouble in time for effective action.

This places an additional task on the ground system. Closed-circuit optical surveillance of the launch site and other optical and electronic instrumentation, tracking equipment, and computers must be provided to allow instantaneous and continuous evaluation of boost system performance and provide for rapid use of the escape system. An unobstructed area must be provided close to the launch site for pilot abort landing and safe recovery.

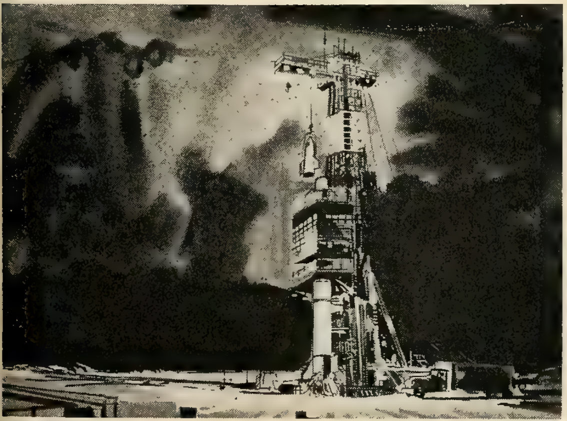
• **Designed-in maintenance**—When man leaves the atmosphere he must carry along his own environment for survival—air to breathe, pressure and temperature control, nourishment, and protection from radiation. Some of these systems will demand servicing and thorough checkout immediately prior to launch, requiring either a unique servicing system or equipment and personnel on platforms high above the ground, Werner said.

As an example, a five-hour orbiting mission for one man would probably require 200 pounds of liquid nitrogen-oxygen for breathing atmosphere, 90 pounds of nitrogen for equipment conditioning, 400 pounds of hydrazine for turbine system accessory power, and 400 pounds of chilled water as a heat sink for evaporative cooling of the man and his equipment compartment.

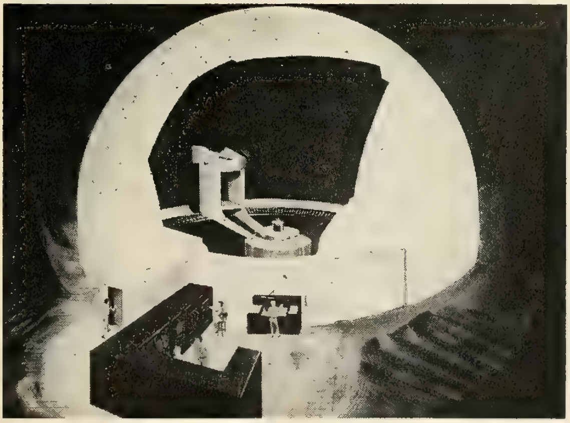
These servicings would be topped off immeditely prior to launch and have automatic disconnects. In addition, cool-air servicing for the man's compartment during preflight checkout would be necessary to reduce the demand on the on-board expendables. Another interesting requirement would be meticulous cleaning in the compartment to prevent any distraction to the pilot caused by floating dust and small particles during weightless flight.

• **Communications**—Adding man to the space system increases communication system requirements. Both new and existing facilities must be integrated into a global communications network. Additional radar tracking stations must be considered, since the need for locating and recovering the vehicle, particularly during an emergency re-entry, would require a capability in excess of that in existence or planned for. Ground tracking facilities also may be needed to provide significant flight parameter information to

Costly and elaborate launch complexes . . .



Expensive training aids . . .



the vehicle in case of primary navigation system failure.

With a man in the system, two-way voice communication would certainly be desirable. Such facilities would permit transmission of information to and from the vehicle and provide both a psychological benefit to the pilot and an effective way of evaluating his condition and ability to complete the mission.

• **Recovery**—The man in space must be gotten back intact, healthy, and willing to go out again on other missions. This means that an effective landing or recovery system must be provided. Here the ground support requirements are new and different from those of an unmanned system, Werner said. Landing sites must be prepared and equipped for scheduled recoveries and an effective and reliable system for cases of emergency deorbit prior to scheduled re-entry provided.

When touchdown is completed, radiation cleaning and vehicle cooling may be required before the pilot is removed. Handling and transportation of the vehicle back to the home launch base would be the next job.

• **Personnel training**—Obviously, the system must be manned with trained, competent personnel. The pilot and other crew members and the ground support personnel must be trained individually and as an integrated team. The training system must emphasize the need for absolute reliability throughout the system complex. Personnel failure can be just as disastrous as equipment failure.

All known training techniques and training devices must be used. The use of simulators is particularly important, since actual training flights are much too costly for extensive use. The training program must be designed not only for the development of proficiency but for the selection of suitable individuals for each of the demanding skills. Finally, complete flight crew confidence must be instilled and maintained in both the mechanical and human elements of the system.

• **Costs**—Space systems, especially manned systems, are going to be expensive. The word economical is difficult to use when speaking of such systems, but extensive efforts must be made to minimize the cost. The role of the ground system must not, of course, be emphasized out of proportion to its importance, but since it does represent a significant percentage of total cost, a major contribution can be made in this area.

Discoverer, Yes; Vanguard, No!

Polar satellite capsule is believed to have reentered; magnetometer try invalidated by second stage trouble

by James Baar

Washinton—The United States for the first time attempted a one-two assault on space on the same day with a double satellite launching.

The result: Success over the Pacific. Failure in the Atlantic.

The Air Force at 4:18 P.M. EST on April 13 launched a modified two-stage Douglas *Thor* from Vandenberg AFB. It successfully placed a 1600-pound *Discoverer II* satellite into a polar orbit ranging from 156 to 243 statute miles.

NASA at 9:49 P.M. EST the same day launched a regular three-stage Martin *Vanguard* from Cape Canaveral carrying two satellites. The second stage failed to ignite and the rocket fell into the sea.

Scientists said they plan another *Vanguard* launching carrying two similar satellites—a 22.6-pound lollipop-shaped cylinder and a 30-inch inflatable plastic-aluminum balloon—in the near future.

• **Mixed Success**—Two prime goals of the *Discoverer II* launching were:

—Testing of equipment designed to guide and stabilize a satellite in orbit for the first time, paving the way for development of an observation satellite.

—Re-entry and recovery of a 195-pound capsule ejected from the *Discoverer* on command. The capsule is designed to carry animals into space in future launchings.

ARPA, overall director of the *Discoverer* test series, and the Air Force said the first goal was achieved along with successful testing of launching, propulsion and communications techniques.

However, failure of a timing device made it impossible to eject the capsule as planned near the Hawaiian Islands where Air Force planes were waiting to attempt to catch the capsule with nets.

Still ARPA had an ace in the hole—an automatic "fail safe" device to eject the capsule on the satellite's 17th pass around the earth. Official spokesmen said telemetered data indicated the ejection took place over the Arctic ice cap and the capsule's retro-rockets and parachute were working.

• **New equipment**—The entire 19.2-foot satellite—actually the *Thor's* Lockheed-built second stage—contained the new stabilization equipment designed by Bendix Aviation Corp.

Previously, satellites have tumbled as they orbited the earth. The stablization equipment was designed to hold this one steady in flight.

The satellite also contained a new infrared horizon scanner designed by Advanced Technology Laboratories and an inertial guidance system produced by Reeves Instrument Corp. to overcome previous guidance problems of orbiting vehicles.

A Lockheed telemetry system capable of making more than 100 measurements radioed performance data to tracking station at Vandenberg, Hawaii and Alaska.

A total of 165,000 pounds of thrust put *Discoverer II* into orbit. The liquid-propelled Rocketdyne engine of the *Thor* provided 150,000 pounds. The liquid-propelled Bell engine of the Lockheed second stage provided the remaining 15,000.

The *Thor* weighed over 100,000 pounds. The second stage weighed 8400 pounds before launching.

The two-stage vehicle placed *Discoverer II* in a nearly circular orbit with an orbital period of 90.84 minutes. Its estimated lifetime was about one month.

Launching of the big satellite was the first major success in the *Discoverer* series. The first *Discoverer* launched Feb. 28 from Vandenberg was believed to have gone into orbit, but because of a transmitter failure the Air Force was unable to track it.

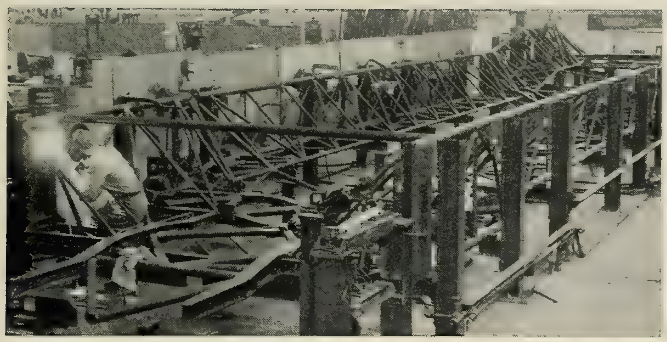
The *Vanguard* failure was the seventh out of nine *Vanguard* launchings attempted so far.

The lollipop satellite contained a highly sensitive magnetometer designed to provide much-sought data about the earth's magnetic field.

The magnetometer—the most sophisticated used to date—makes its measurements on the basis of the free precession of protons around an electric current. It was developed by Varian Associates.

The .44-pound balloon would have been inflated with nitrogen after being ejected from the payload. It would have measured the density of space.

Goodyear's Approach for *Atlas* GSE



CRADLE FOR *Atlas* missile begins to take shape as I beams and cross braces are welded together.

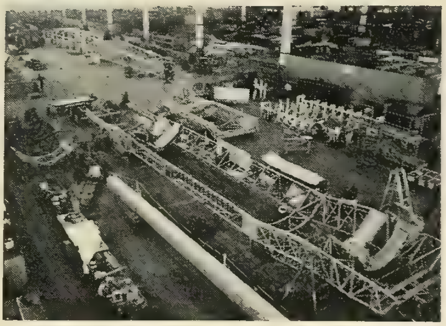
PHOENIX — Goodyear Aircraft's Arizona Division is now producing a new line of mechanical ground support and launching equipment for *Atlas*. Some $4 million in add-on orders recently were received from Convair, bringing production to a new high.

Equipment being produced at Litchfield Park includes a missile handling trailer, an allied booster handling trailer which transports the missile's booster separately and can position itself back-to-back with the missile trailer for installation purposes, engine gimbaling support stands, erection boom, its support and associate drive mechanism, and alignment rails and gages.

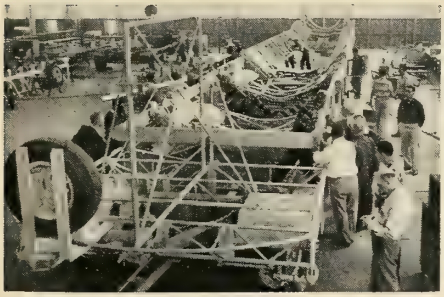
Goodyear points out that the new GSE permits rapid erection of the *Atlas* to launch position and quick replacement by another missile soon after firing. The familiar 13-story gantry tower, an integral part of previous *Atlas* launching complexes, is eliminated.

Goodyear has been associated with the *Atlas* program since 1955 when the first of a number of giant over-the-road transport trailer-erectors was built here. The transport has been used to carry the 80-ton ICBM to various test centers, including Cape Canaveral. The Arizona plant also produces ground support equipment for Martin's *Mace*. Other work on *Mace* is being done at the Akron plant.

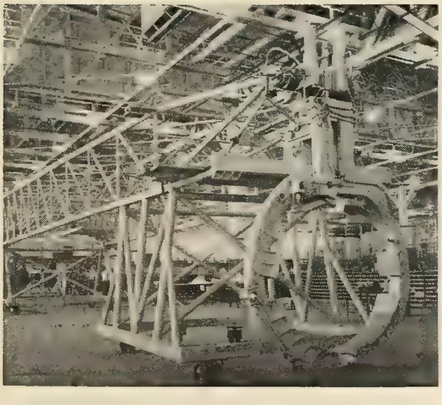
A multi-million expansion program for constructing acoustic chambers for testing electronic equipment is underway at the Arizona division. The new facilities will enable Goodyear to conduct studies on a wide variety of problems created by sound waves of space age vehicles. Sound pressure levels of 150 db in a frequency range of 37.5 to 10,000 csps will be produced in the test chambers.



OVERALL production line at Goodyear's Arizona plant. Long framework in center is 74-foot transport trailer nearing completion.



TECHNICIANS give final check to missile transport trailer and booster and nacelle carriage before taking out for road tests.



THIS huge clamp on forward end of *Atlas* missile-carrying trailer fits near nose section and holds missile in position while in transport to launching sites.

NASA May Have to Ask for More Funds

Eight satellite launchings, 2 space probes and 45-50 sounding rockets may require additional funds above requested $485 million

WASHINGTON—NASA could spend more money fruitfully in fiscal 1960 and the civilian space agency may have to ask Congress later for more than its presently requested $485 million FY budget.

These are impressions gained from reviewing the testimony by NASA's technical experts before a subcommittee of the Senate Aeronautical and Space Sciences Committee.

The agency outlined a program which includes the launching of eight satellites, two space probes, and from 45 to 50 sounding rockets during 1959; and six satellites, four space probes, and from 90 to 100 sounding rockets in 1960.

NASA's budget requests are based on the premise that certain vehicles, propellants, and scientific instruments will not be ready for use in FY 1960, and that R&D on future space systems will only need to be funded at a budget-predicted rate.

But extra funding will be needed to take advantage of the time saved if technological breakthroughs occur in any of these fields.

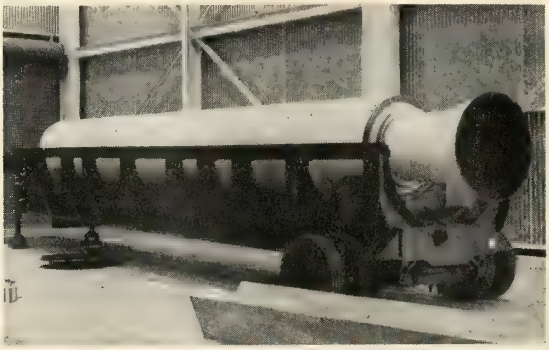
Vehicles which NASA expects to be the work-horses in space research during the next few years but which are not expected to be ready for use in FY 1960 are *Scout, Vega,* and *Centaur.*

Scout, a four-stage solid-propellant satellite launcher and sounding rocket, can orbit 150 pounds at 300 miles and send 1000 pounds in a vertical probe to 12,000 miles. Its test firing date is late this summer. Production is expected in June, 1960. It is funded in the FY 1960 budget for only $2 million, and yet its cost per vehicle is $500,000.

Vega, is a modified *Atlas* with a General Electric *Vanguard* engine which has start and restart capability as its second stage, and a 6000-lb.-thrust storable solid 6K engine by JPL as its third stage. It is scheduled to put a 5800-pound meteorological satellite in a 300-mile orbit, a 740-pound communications satellite in a 22,400-mile orbit, and to send large payloads of 1000 pounds or more to the moon and nearby planets. First firings are due late in 1960 and its production date is expected to be sometime in 1961. It is funded in the FY 1960 budget for $42.8 million.

Centaur, a modified *Atlas,* with a high-energy liquid oxygen and hydrogen engine (Pratt & Whitney) as its second stage and the JPL 6K on top, has a greater lift capability than *Vega* and will be ready at approximately the same time. It is funded for $41 million in NASA's FY 1960 budget.

In the FY 1959 budget NASA was able to transfer funds from one project to another as technology advanced. But many NASA scientists believe R&D projects in the FY 1960 budget will not be as flexible as they were in FY 1959.



AEROJET-GENERAL will supply the solid fuel second stage for NASA's "all-purpose" ***Scout*** **vehicle.**

Technological advancements in nuclear engine research since NASA prepared the budget could make this program demand more funds. In the FY 1960 budget, Project *Rover* is funded for $2 million and nuclear engine R&D is funded for $8 million.

Another project which could upset the budget, if it progressed faster than expected, is the one million pound single chamber engine (*Nova*) which is funded in FY 1960 for $30.2 million.

Most of the FY 1960 experiments will use existing hardware, and instrumentation which is ready now or in the near future. The difference between sending six probes, or 16 probes into the solar system of the type NASA contemplates, is largely a matter of money.

The House last week approved an Administration plan for increased spending on the *Mercury* program.

It passed and sent to the Senate by voice vote without audible dissent an Administration bill authorizing an appropriation of $48,435,000 in supplemental funds for NASA for the current fiscal year. The actual cash would be provided in a later appropriation bill.

The requested supplemental funds include $20,750,000 for research and development, all of it earmarked for the manned space flight program—Project *Mercury.*

The measure also authorizes $24,250,000 for construction and equipment and $3,354,000 to cover cost to the agency of federal pay raises enacted by Congress last year.

Orlando Expansion

LAS VEGAS—Two items were uppermost among industry at the World Congress of Flight:

(1) Northrop is hoping to get AF support for its concept of a space trainer, possibly using a modified T-38 trainer and;

(2) Companies interested in commercial space flight applications may have to finance a new facility like Palmdale, probably in Orlando area with flights at the Cape.

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Nuclear Explosions in Space

- ***Many techniques exist for detecting trapped particles***
- ***But high-altitude bursts at some latitudes might leave no traces***
- ***Adequate inspection procedures may be difficult to establish***

Last of four articles by
PROF. S. FRED SINGER

WASHINGTON—It is difficult to overestimate the scientific importance of high-altitude atomic tests as a tool for probing the environment of the earth. The principal announced result of the *Argus* tests—the finding that the shell of trapped electrons remains fixed in position in space—already tells us a great deal about the origin of the earth's natural radiation belts.

In addition to satellite measurements of the *Argus* electrons trapped in the magnetic field, there are a variety of unconventional scientific measurements which would reveal much about the properties of the outer atmosphere of the earth, its state of ionization, behavior of the magnetic field out to a distance of several earth radii, and the propagation of hydromagnetic waves in this medium.

The various scientific methods for detecting the effects of space bursts have rather obvious political significance as well. The immediate question raised by the *Argus* tests is whether it is possible for a nation to conduct atomic explosions in space in secret. Or can all tests conducted in the upper atmosphere be detected by suitable observing stations either on the ground or in balloons, or with satellites?

It must be remembered that atomic tests at high altitudes produce no seismic effect, negligible (if any) fallout, and of course no blast effects.

Nature and Origin of Earth's Radiation Belts

Through a fortunate circumstance the *Argus* tests released electrons which attached themselves to a line of force going out to about one earth radius. It so happens that at this distance (4000 miles) we have the minimum between the inner and outer radiation belts of the earth. The *Argus* observations can now be used to shed important light on the origin of the natural radiation belts of the earth.

The outer belt, it is now generally agreed, has its origin from the sun. A theory for the trapping of solar corpuscular radiation was developed by the writer in 1956 and can now be used to calculate the expected radiation intensity distribution with altitude and latitude.

• **Nature of outer belt**—Here the theory comes to the following conclusion: A most reasonable explanation of the observed distribution with altitude is that the particles are low-energy protons and electrons (below one million electron-volts). The particles cannot be energetic protons (which could penetrate the rocket's skin), and they cannot be very energetic electrons either. It is most likely that rather soft electrons produce X-rays that finally set off the counter.

The falloff of the radiation intensity with altitude in Fig. 1 is predicted by the theory; it gives us the maximum number of particles that the earth's magnetic field can trap. The distribution along the line of force has been calculated from the distribution of the pitch angles of the trapped particles. It can be seen rather easily that the number of particles with small pitch angles (able to penetrate far along the line of force) is rather small. Most of the particles trapped have pitch angles near 90° and therefore move nearly at right angles to the line of force and are incident from that direction.

• **Inner belt**—When trapped radiation was found in the *Explorer* satellites in May, 1958, it seemed to the writer that the trapped solar radiation could not get down this close to the earth at the equator. In looking for other sources of trapped radiation, we found a possible source in high-energy neutrons produced in the earth's atmosphere by incident cosmic rays. Those neutrons which are emitted in an upward direction move outward along straight lines. Only after they decay into a proton and electron can the magnetic field become effective.

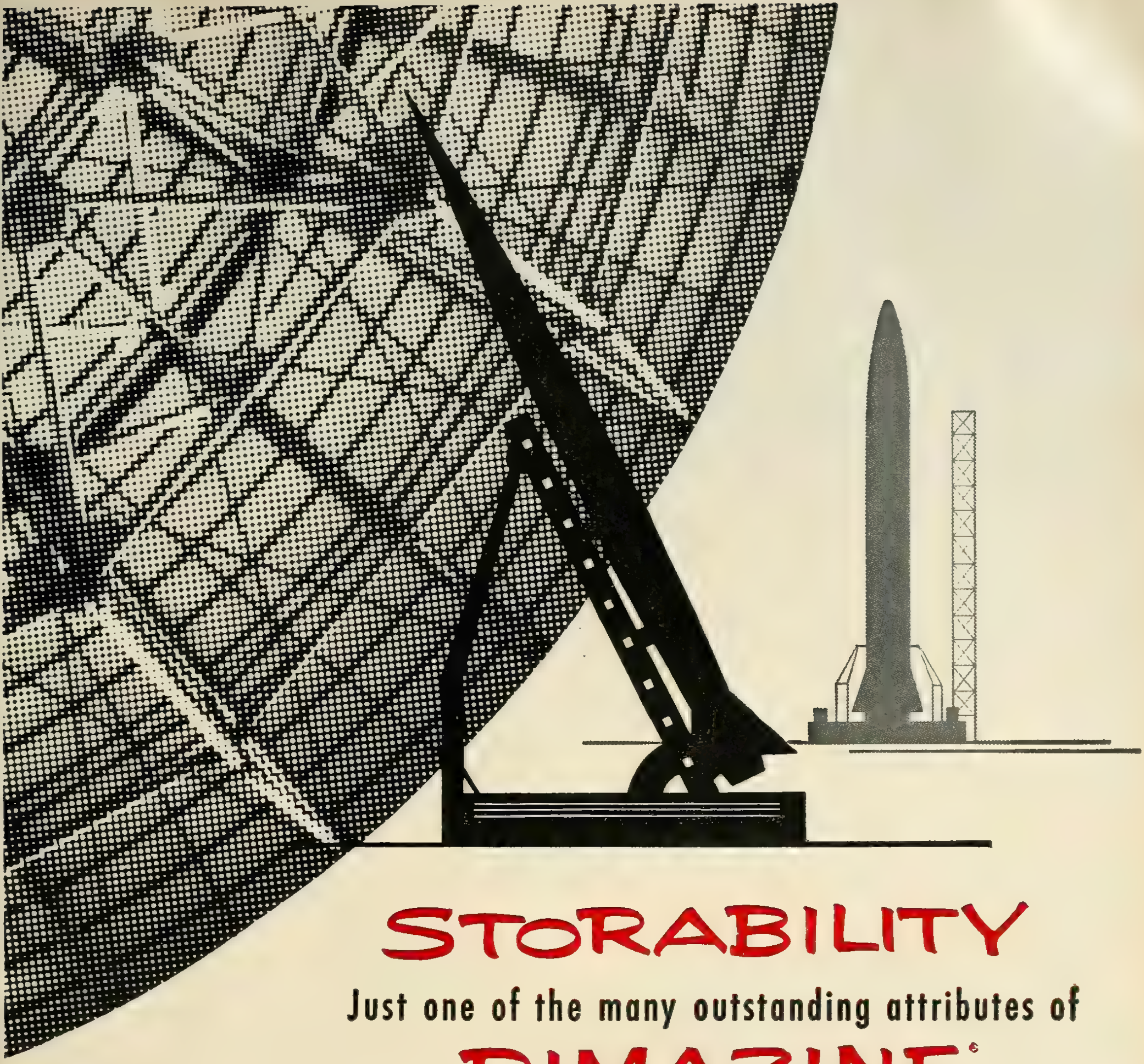
As shown in Fig. 1, the neutron theory leads to a radiation belt close to the earth's equator with a maximum at low altitudes. The trapped radiation

Soviet Claims Discounted

It is interesting to examine the claims of certain Russian astrophysicists that the inner radiation belt is the result of explosions of U.S. hydrogen bombs in Nevada. This statement can be attacked on a number of grounds. In the first place, any radiation released from H-bomb explosions, even if it could get into the trapping regions, would have a very short lifetime—of the order of days—whereas the measurements show that the inner belt is rather constant with time.

Furthermore, if the inner belt indeed consists of hard (energetic) protons, then there would be no way to account for it by H-bomb explosions.

There has been speculation in the press that the Russians really referred to the *Argus* tests, which had not been announced at that time; but this cannot be believed. In the first place, they spoke very clearly of the inner belt; secondly, had they measured *Argus* electrons in the *Sputnik* they would have noticed their very short lifetime and could have drawn the proper conclusions; we can therefore be reasonably sure that they did not in fact make such observations. It appears more likely that their statements were politically inspired, particularly since they were coupled with the assertion that such atomic tests creating radiation belts also affect the earth's weather. That statement cannot be supported by facts.



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itself should consist of very penetrating protons of the order of 100 million electron volts. Experimental data by the University of Iowa group seem now to support the prediction of the theory and indicate that in fact a substantial portion of the inner belt radiation consists of penetrating protons.

The point of view concerning two independent sources of trapped radiation is not universally accepted. One school of thought holds that trapped solar radiation may diffuse downward towards the earth's equator and set up the maximum at low altitudes.

But, as has been pointed out by Christofilos, the constancy and fixed position of the *Argus* electron shell shows that such diffusion through the earth's magnetic field probably does not occur. It therefore gives great support to the point of view that the two belts of the earth are indeed of separate origin: the outer belt from an outer origin—i.e., from the sun; and the inner belt from an inner origin—i.e., effects of cosmic rays on the earth's atmosphere.

- **Countermeasures**—The outer (solar or soft) belt probably presents no great problem. But if the cosmic ray neutron theory is indeed confirmed by further measurements, then the inner hard belt presents a hazard to space flight—a manned vehicle operating in this region for long periods of time would have to carry a large amount of shielding. Without it, doses of a few roentgens per hour would be experienced.

Also, if the neutron theory is correct it predicts long lifetimes for the trapped particles of the inner belt and a small rate of supply. Once the particles are removed, for example by absorbing them in some way, it will take several months or years before they are replenished. If we operate large satellites in the region of the hard belt, they will intercept a large number of trapped particles and absorb them, thereby sweeping out the inner belt region and making it safe for manned operations.

In view of the support from the *Argus* tests, the sweep proposal for the inner belt is greatly strengthened.

One method of removing particles from the inner belt suggests itself—to use carefully controlled atomic explosions in space. By releasing rather non-penetrating fission particles which can disturb the magnetic field, the magnetic field disturbances in turn can release trapped radiation belt particles and dump them into the atmosphere. Calculations by the writer show that this scheme represents a distinct possibility for reducing the cosmic ray belt's intensity.

Unconventional Scientific Measurements

Radiation trapped in the earth's magnetic field can be measured directly by satellites or space probes. In addition, a variety of detection methods can be used from the ground or from balloons to investigate related effects produced by atomic explosions in space.

One of the most interesting phenomena to observe would be the occur-

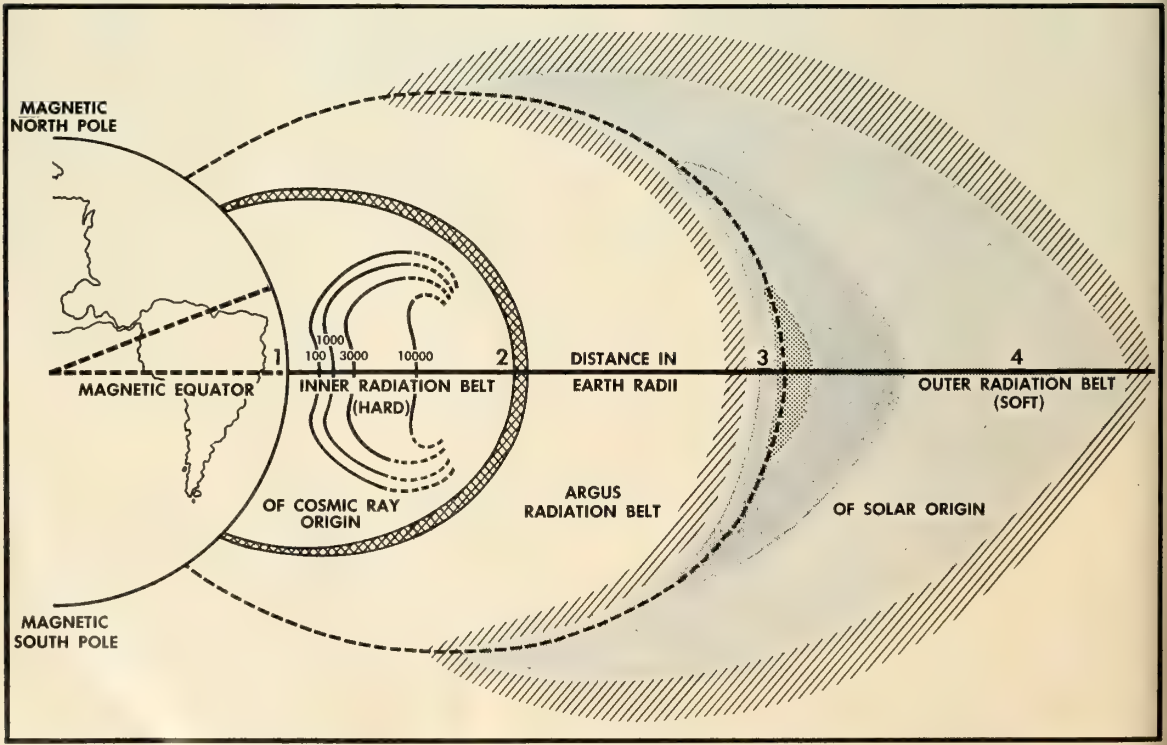
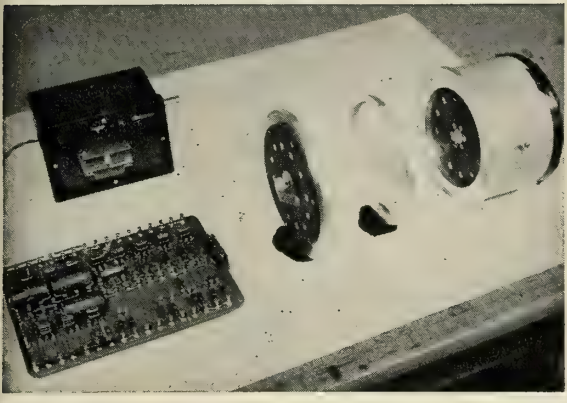


FIG. 1—Radiation belt intensities calculated from theory. For the inner belt, consisting mainly of hard (penetrating) protons, actual counting rates can be calculated. For the outer belt, made up largely of soft (easily shielded) electrons and protons, relative intensity distribution is calculated; the actual intensities will change, as will the position of the belt, depending on the amounts of fast plasma shot out from the sun. Location of *Argus* radiation is shown along the line of force reaching out to two earth radii (8000 miles from center of earth, or 4000 miles above sea level).



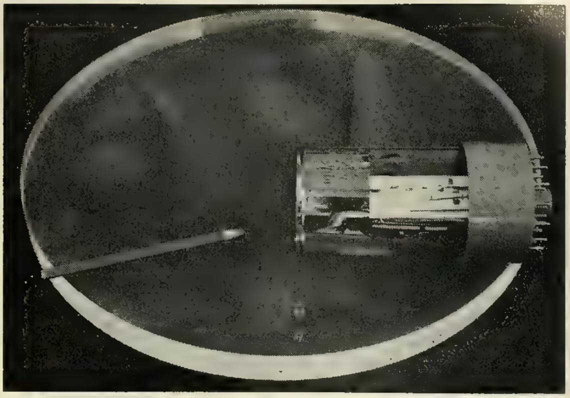


FIG. 2—(at left) Exploded view of ultrasensitive microbarometer which could be used to measure pressure pulses from atomic bursts in space. Black box contains Decker Corp.'s T-42 transducer (Courtesy Prof. W. Kasner).

FIG. 3—(at right) Large disk-shaped plastic scintillator for observing effects of incident fission electrons in the lower atmosphere. Light from the scintillation is guided by a cone (not shown) into a sensitive DuMont photomultiplier which puts out an electrical voltage pulse (Courtesy Prof. W. R. Webber).

rence of magnetohydrodynamic pulses produced in the earth's outer atmosphere by atomic explosions, principally by their fission fragments. We have calculated the effects to be expected and find that the waves would propagate with speeds of the order of several hundred miles per second; they would follow very closely along the magnetic lines of force and would be mostly reflected when they are incident on the earth's ionosphere at several hundred miles altitude. However, their effects could be detected at sea level, at balloon altitudes, in the ionosphere, and higher.

Above the ionosphere one direct way of looking for magnetohydrodynamic waves is with a rocket or satellite-borne magnetometer. One expects to find waves which are produced naturally in the auroral zone by trapped solar corpuscular radiation. They have a characteristic spectrum whose form can be calculated from geophysical data.

These waves should also produce magnetic effects at sea level, and in fact magnetic effects are observed in auroral latitudes, the so-called geomagnetic micropulsations. We believe that they are produced by magnetohydrodynamic waves above the atmosphere and would expect that atomic explosions will similarly produce such micropulsations at sea level. We have calculated the characteristic magnetic "signature" of an atomic explosion and find that it should lead to a decrease in magnetic field which is rather sharp, followed by a recovery and a slight increase. The effects observed below the ionosphere are of course smaller than those above the ionosphere.

• **Balloon detection**—An important tool for observations is the balloon platform. It is still the only means for making high-altitude studies over a long time at a relatively fixed geographic position.

Extremely interesting measurements can be made at a location where such a magnetohydrodynamic wave is incident. As the energy of the wave couples from the ionosphere to the lower neutral atmosphere a small fraction of the energy goes into acoustic form. A highly sensitive microbarometer has been designed (see Fig. 2) which may be able to pick up and "listen" to atomic explosions in space. Its high sensitivity is due to its unique design as well as to the use of a newly-developed ionization transducer.

From balloons one can also observe the incidence of trapped electrons into the upper atmosphere. A fraction of one percent of these electrons will produce gamma rays before they come to rest. These rays have a considerably greater range than the original electrons and will therefore propagate down to altitudes as low as 70,000 feet. The most sensitive instrument for detecting their presence is a so-called scintillation crystal coupled with a sensitive photomultiplier. An example of such instrumentation designed for balloon operations is shown in Fig. 3. Its large collecting area gives high sensitivity for incoming gamma rays.

• **Artificial aurora**—Most of the particles from the explosion, when incident on the upper atmosphere, will produce excitations of atoms and therefore an artificial aurora. It could be observed from the ground or from airplanes if it occurred at night, but to observe an aurora during the daytime requires special optical equipment carried in balloons. A spectrograph designed for automatically recording daytime aurora is shown in Fig. 4. It uses a concave grating "blazed" in the red where much of the energy of the auroral emissions is concentrated, and incorporates various features to reduce the effect of the daytime sky brightness.

• **Artificial radio "whistlers"**—A further consequence of an atomic explosion in space is the creation of a large number of ionized particles. As positive and negative particles become separated, at least for a short time, the sudden creation of a charge distribution should produce a radio signal. The very low-frequency radio waves propagate with low speeds very nearly along the line of force. But, as has been observed for natural "whistlers" produced by lightning discharges, the higher frequencies move with slightly higher speeds. As a result they arrive first, and what is observed on the ground is an audio tone which starts with high pitch and drops to low pitch in a second or so; hence the name "whistler." The necessary receiving equipment may consist only of a long wire antenna feeding into an audio amplifier.

• **Artificial radiation belt**—The various scientific measurements discussed above are of course important for telling us more about the interaction of charged particle radiations with the earth's magnetic field and the earth's outer atmosphere. In turn this leads to badly needed information about the outermost atmosphere, the so-called exosphere.

For example, by comparing the theory of the radiation belt with experiments, it should become possible to measure and determine the atmospheric density in the exosphere.

A much more convenient method for studying the exosphere or the magnetic field is by artificial injection of particles to form artificial radiation belts of the earth. The use of accelerators carried in rockets and satellites has been suggested independently by Christofilos and by the writer. Such experiments would allow us to test in detail the atmospheric density at various levels above the earth and to monitor continuously the state of affairs of the earth's magnetic field above the ionosphere to determine whether it is quiet or disturbed.

Inspection of Atomic Explosions in Space

Aside from their scientific applications, the detection methods discussed determine whether atomic bursts in space can be detected or can be carried out in secret—a very pertinent question in view of current efforts to set up an international test ban for nuclear weapons.

It is difficult to give a definitive yes-or-no answer since so much information on the effects of high-altitude atomic bursts is based on theory and not on direct measurements. But the following conclusions stand out:

An atomic burst at high altitudes, say above 1000 miles or more, should lead to trapped radiation which can easily be detected by means of satellites. However, if the line of force along which the explosion takes place is at an auroral latitude, then the radiation released may blend in with the naturally present auroral radiation and might escape notice. For polar (magnetic) latitudes (above the auroral zone) the earth's magnetic field is no longer able to trap particles and they will escape into interplanetary space.

A different problem is posed by explosions at rather lower altitudes, of the order of 100 to perhaps 500 miles. As explained earlier, if the burst takes place over a magnetic "high" then practically none of the radiation will be trapped; it will instead be dumped into the opposite hemisphere.

Reference to our magnetic map (Fig. 1 in part 3 of this series) shows that it would be extremely difficult for the Russians to carry out an operation like *Argus* and escape detection. It is not possible to dump radiation into the Russian ionosphere without at the same time trapping a large fraction of the radiation for several days.

While effects occurring in the ionosphere above Russia might escape detection by Western observers, effects in the immediate vicinity of the explosion could be detected. Scientific methods for measuring the state of the ionosphere, in particular the propagation of radio waves, could indicate the occurrence of atomic tests. But setting up adequate inspection procedures may turn out to be a difficult technical problem because of the lack of adequate data.

Although U.S. negotiators have proposed only barring nuclear tests up to 30 miles in altitude, it is conceivable that a nuclear test ban may include tests in space as well as in the atmosphere. In that case, Project *Argus* will go down in history as a unique peaceful application by the United States of nuclear weapons designed for destruction. There is little doubt, to my mind, that *Argus* constitutes one of the truly important geophysical experiments of our time.

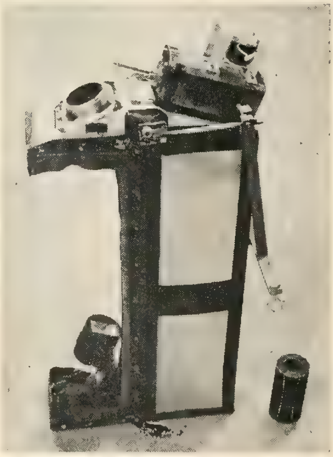


FIG. 4—Spectrograph designed to detect daytime aurora from a balloon. Half of the cover has been removed to show concave grating which is "blazed" to put most of light coming through slit (upper left) into red portion of the spectrum. Recording is done with specially sensitized film in cassette (upper right). Holder for filmstrips is shown next to spectrograph. Basic design of instrument follows that of Dr. R. Tousey, Naval Research Laboratory (Courtesy Profs. H. Griem and E. Hinnov).

Hughes Develops Complete Radiation Lab Service

CLEVELAND—A package radiation test laboratory including a robot "hot" material manipulator has been developed by Hughes Aircraft Company. Announced at the 1959 Nuclear Congress and Atom Fair, the company said it will provide a complete service for radiation facilities and lab equipment to meet specific customer requirements.

The service will include a "Linac," an extremely high current linear electron accelerator. Reported to be the "most powerful of its kind," it is considered to be less expensive than a reactor and, under certain conditions, is better for performing nuclear research.

Nuclear reactor radiation simulators, cobalt radioactive sources, gamma or neutron Linacs, pulse or test reactors can also be provided. A gamma Linac now being manufactured can be used for flash testing components by bombarding them with a short, intense pulse equal to the radiation of an atomic or hydrogen bomb. The traveling-wave type of linear electron accelerator operates at 10 megavolts or more.

The manipulator, Mobot Mark I, is designed to work in dangerously radioactive rooms. It can even operate in deep water, the company said. Looking much like a fork-lift machine, the device is operated remotely from a console control center.

A microphone and closed-circuit TV provide "ears and eyes" for the operator. Capable of operating with tweezer-like care or with a 200-pound squeeze, Mobot can be directed electrically or by radio.

The equipment will be sold to research institutes and universities in addition to industry. The Linac accelerators and pulse reactors are being used to "flash test" parts used in the armament control systems of Air Force all-weather interceptors.

Hughes says the Linacs are far cheaper than reactors and under some conditions can serve the purpose better for facilities wishing to conduct nuclear research.

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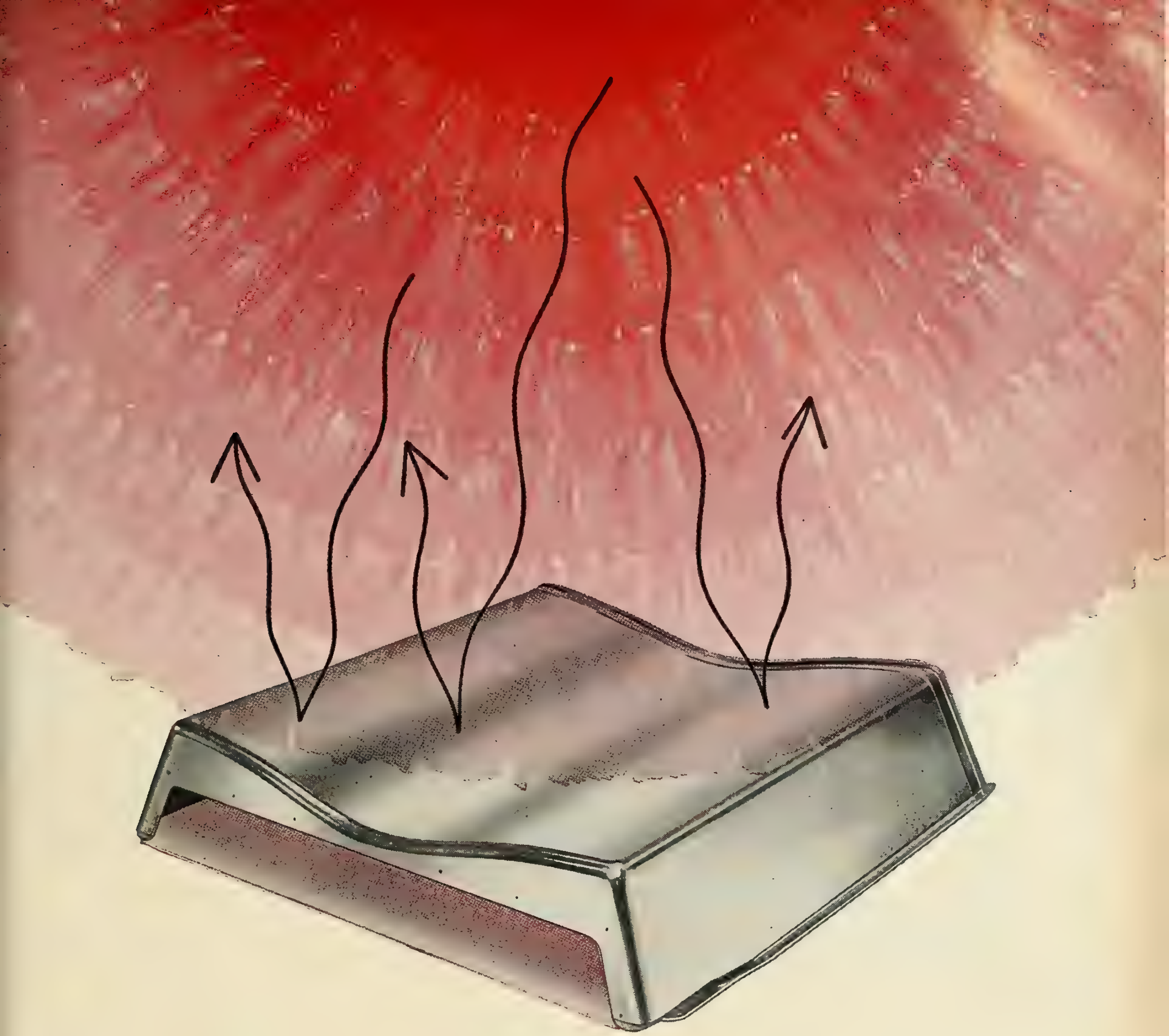
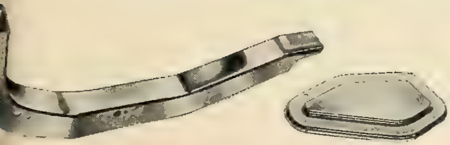
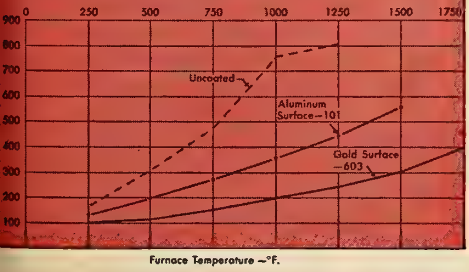


low, reflect up to 1750°F radiant heat from SWEDLOW metallized laminates





Typical example of heat reflection
Glass cloth-silicone laminate X5G-138, thickness .060 in., placed across electric furnace aperture. Chart shows comparative temperatures.

Compound shapes—minimum weight and bulk—highly efficient reflectivity—distinguish these materials and solve the problem of resistance to elevated temperatures.

Swedlow's solution for light weight heat protection problems uses a base of fiberglass fillers. To these are added any of an impressive variety of silicone, phenolic, epoxy, TAC polyester or polyester binders to meet specific service conditions. The resulting high-strength laminate is furnished flat or molded to any contour desired. Metallic coatings then further increase heat reflectivity and resistance. Swedlow-pioneered Type -101 aluminum coating is now in wide use for the 200°F to 1400°F range. The more recently developed Type -603 gold now raises the limit to approximately 1750°F.

Swedlow research is continuing the development of many combinations for the growing variety of aircraft, missile and electronic applications. To learn how these new materials can help solve your heat problems, contact the Swedlow plant nearest you. Or send for new literature—"Radiant Heat Reflective Laminates." Please refer to Dept. 21

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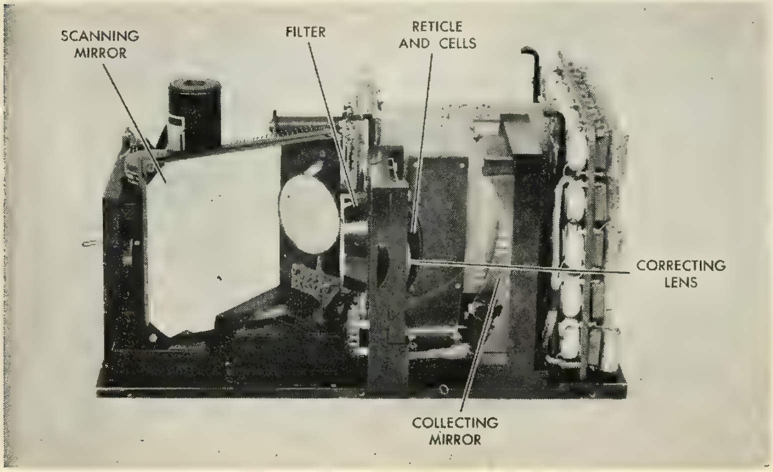
Avion Develops New IR Search System

CODES, built around commutating infrared detector, will be modified for satellite tracking

by Charles D. LaFond

PARAMUS, N.J.—A significant development in air-to-air infrared (IR) search systems was demonstrated for the first time at the World Congress of Flight in Las Vegas. It offers 10 times the sensitivity of other IR search receivers and three times the range of any known small air-to-air missile, according to its developers, Avion Division of ACF Industries, Inc.

Key to the advance, Avion said, is the use of an "ac commutating" IR detector. Avion's chief research consultant, Joseph Schwartz, developed the commutated cell technique and was responsible for building the first demonstration system.



AVION's CODES IR detection system (cover removed) reportedly has 10 times the sensitivity of other search systems.

Under a prime contract for the Air Force Cambridge Research Center, a modified version of the system is being developed by Avion for satellite detection and tracking.

The company believes that the commutating IR detection system, called CODES, demonstrates the feasibility of a low-level storage and sampling technique for achieving high sensitivity and fast coverage. Of simplified design, the multichannel wide-field receiver employs single-channel electronics. Its developers believe CODES provides many advantages over conventional multi-element systems, and does so with a single amplifier.

The demonstration receiver, (Fig. 1), is packaged in a case measuring 8 x 13 x 7 inches overall. Including a five-transistor amplifier, the whole system weighs only 15 pounds. (Table 1 is a partial list of parameters.)

• **Past efforts**—In the design of infrared search sets, much effort has been applied to increasing detection sensitivity and reducing equipment complexity. Finding a practical solution based on today's state-of-the art materials necessarily has narrowed the field of potential techniques.

Although it is well-known that an increase in the number of detectors will increase sensitivity, most IR search sets now in use employ single cells. To scan a given field, a complicated system of motors, mirrors, and cams is required for the single cell. But an increase in detectors normally results in an increase in amplifiers. Therefore, an increase in electronics results from a decrease in mechanical design. This rapidly becomes prohibitive.

Avion has been a pioneer in its largely self-sponsored research and development work in IR detection and tracking. Temporarily sidestepping its hoped-for design of a thermal imag-

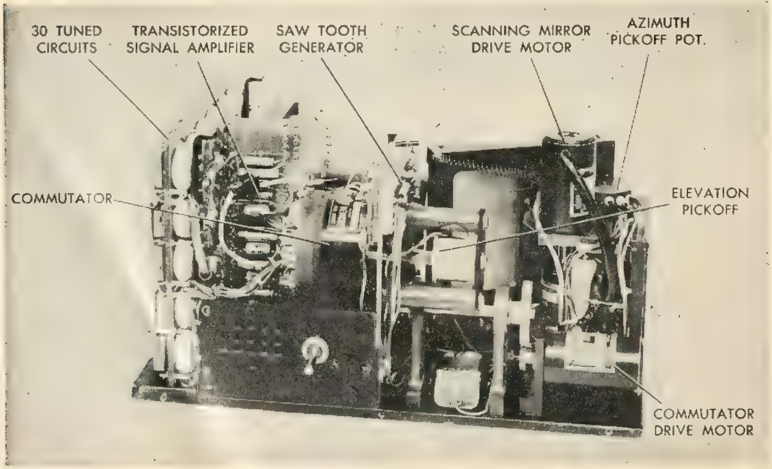


TABLE 1: SOME PARAMETERS OF CODES

SEARCH FIELD	
Total search field	±45° azimuth by ±20° elevation
Instantaneous field	2.7° azimuth by 40° elevation
Frame time	1.5 sec, 2 fields per frame
CELLS (LEAD SULPHIDE)	
Size	1 by 2 mm
Jones S of cells (Sensitivity)	4 x 10^{-10} in 1.8 to 2.7-micron band
Time constant	200 usec
Field of view per cell	2.7° azimuth by 1.3° elevation
OPTICS	
Effective input aperture	1.7-inch diameter
Optical efficiency	30%
Net free aperture	4.4 cm^2
F number	f/1.0
Resolution	1.2 milliradians
Angular spot size	90% of energy in 1 milliradian
POWER REQUIREMENTS	
Motor drive	400 cps, 115 v ± 5 cps
Cell bias	120 v dc, 1.5 ma
Amplifiers and pickoffs	28 v dc, 20 ma

ing vidicon, Avion reduced the available solutions to one more immediately feasible—the multiple cell-single amplifier approach.

- **Design philosophy**—In designing the demonstrator equipment, Avion did not consider such factors as weight reduction, size limitation and optical efficiency. Future operational units, the company said, will reflect the optimum in design details consistent with the state of the art. But its designers believe that a typical operational version of CODES will weigh less than 10 lbs. and will be contained in a package 8 x 6 x 6 inches overall.

The demonstrator was designed to emphasize simplification and high performance. The feasibility of commutating detectors for greater capability in the general air-to-air search problem was the ultimate goal.

- **Operation**—Essentially, CODES functions in the following manner: Scanning action by an azimuthal rocking plane mirror provides IR input for a spherical optical system. A highly sensitive, multi-cell linear array provides detection, and the output of each cell is stored in a passive LC "tank" network before commutation. By means of a mechanical commutator, an amplifier sequentially samples each tank output. Thus, each cell sweeps out its portion of the field of view. The presence of a target is announced by ringing action in the tank; the ac signal is sampled by the commutator, and then amplified for visual display.

- **Design details**—A plane mirror rocking in azimuth and coupled with a position pickoff provides the scanning action and input to a concentric optical system. Gimbals are not used.

The optical configuration (concentric catadioptric) employs spherical surfaces only. As indicated in Fig. 2, following the plane mirror filter, a correcting lens, image surface, and an aperture stop comprise the optics. The aperture stop is located in the plane of the center of curvature, causing all IR rays to be meridional. An interference type filter at the center of curvature transmits in 1.8 to 2.7-micron band. Measured spot size (monochromatic and chromatic) is approximately 1.2 milliradians. Excellent resolution is achieved uniformly over the full field.

With a simple straight-line reticle pattern having a line spacing of nearly 0.0017 in., the reticle itself is formed on a curved surface, 1.25 in. long x 0.15 in. wide. Its 60 equal and alternately opaque and transparent lines are normal to the scanning path. Signal angular chopping is provided at 8 cycles per degree.

Typical of most airborne search applications, a 40° x 90° total field of scan is provided. A 2.7° instantaneous azimuth field permits a commutation rate of 1200 bits/sec.

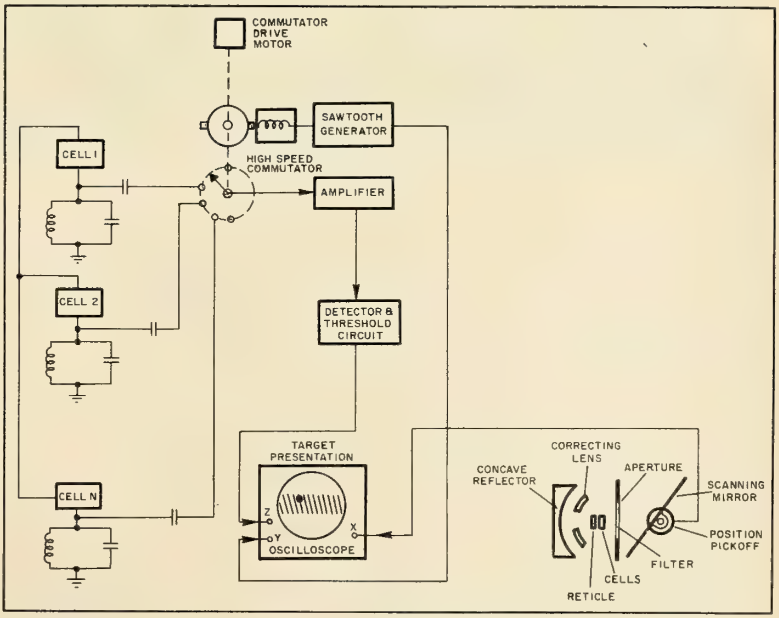
Thirty uncooled lead-sulfide cells, deposited on a curved surface, comprise the linear array. To optimize sensitivity, system bandwidth is consistent with time on target (0.023 sec.). Bandpass is provided in the 30 parallel-tuned circuits driven by the cell signals. Tuned-circuit bandwidth is 40 cps.

For low-level commutations, a 60-segment mechanical commutator, similar to those used in telemetering, is provided. The 30 signal channels are connected to produce two commutation cycles per rotation. To "unload" each tuned circuit during commutation, a resistor is included in the commutator arm.

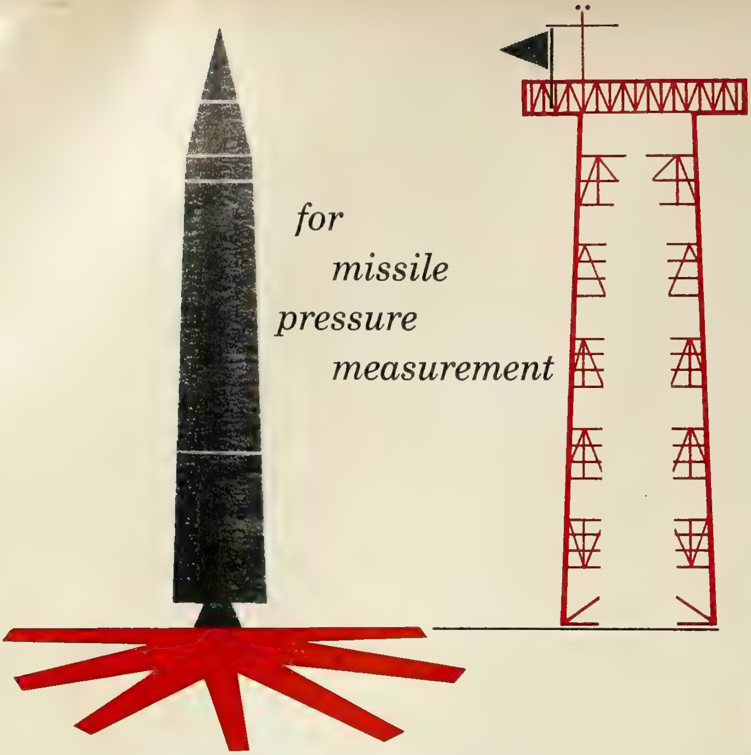
Energy stored during integration drives the amplifier. The 1200-bit/sec. commutation rate commutates 0.75 cps of the 934-cps signal.

Peak-signal detection is guaranteed after amplification by full-wave detection in the signal amplifier. A threshold level then is set to permit positive target definition. To drive the Z-axis on an oscilloscope display, sufficient voltage is supplied by the addition of an-

(Continued on page 73)

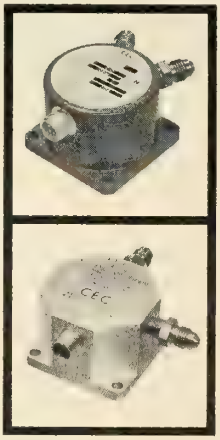


CODES reportedly has three times the range of other IR air-to-air missiles.



TWO POTENTIOMETER PRESSURE PICKUPS

Designed for missile applications, these two pot pickups, the 4-380 for low pressure and the 4-381 for high pressure, are built to exceed severe environmental requirements for in-flight measurements. Rugged construction provides both pickups with a high order of accuracy and reliability for missile work.



Low Pressure Type 4-380 Measures absolute, gage, or differential pressures in ranges from 0 to 100 psi. A miniaturized assembly of counter-balanced flexure pivot design is connected directly to the pressure summing capsulé and is capable of withstanding mechanical shocks up to 75 g's without damage or calibration shift. The internal element is hermetically sealed and completely isolated from the pressurizing media.

High Pressure Type 4-381 For extremely accurate pressure measurements, in the ranges from 0 to 100 up to 0 to 5000 psi, this gage, absolute, or differential Bourdon-tube pickup incorporates a unique wiper arm which eliminates all mechanical multiplication linkages, thus enhancing the pickup's repeatability and resistance to vibration. The pressure sensing element is oil immersed for damping and is isolated from the pressurizing media. The stainless steel case is fail safe to 7500 psi.

For complete information, call your nearest CEC sales and service office or write for Bulletins 1604-X11 and 1611-X8.

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D-P's Growth

Daystrom-Pacific to Enter Systems Work

by Richard van Osten

Los Angeles—Jumping into systems engineering is expected to boost Daystrom-Pacific's missile business to approximately 85% of its total volume within the next six months. This is the confident prediction of officials at the Daystrom, Inc. division here.

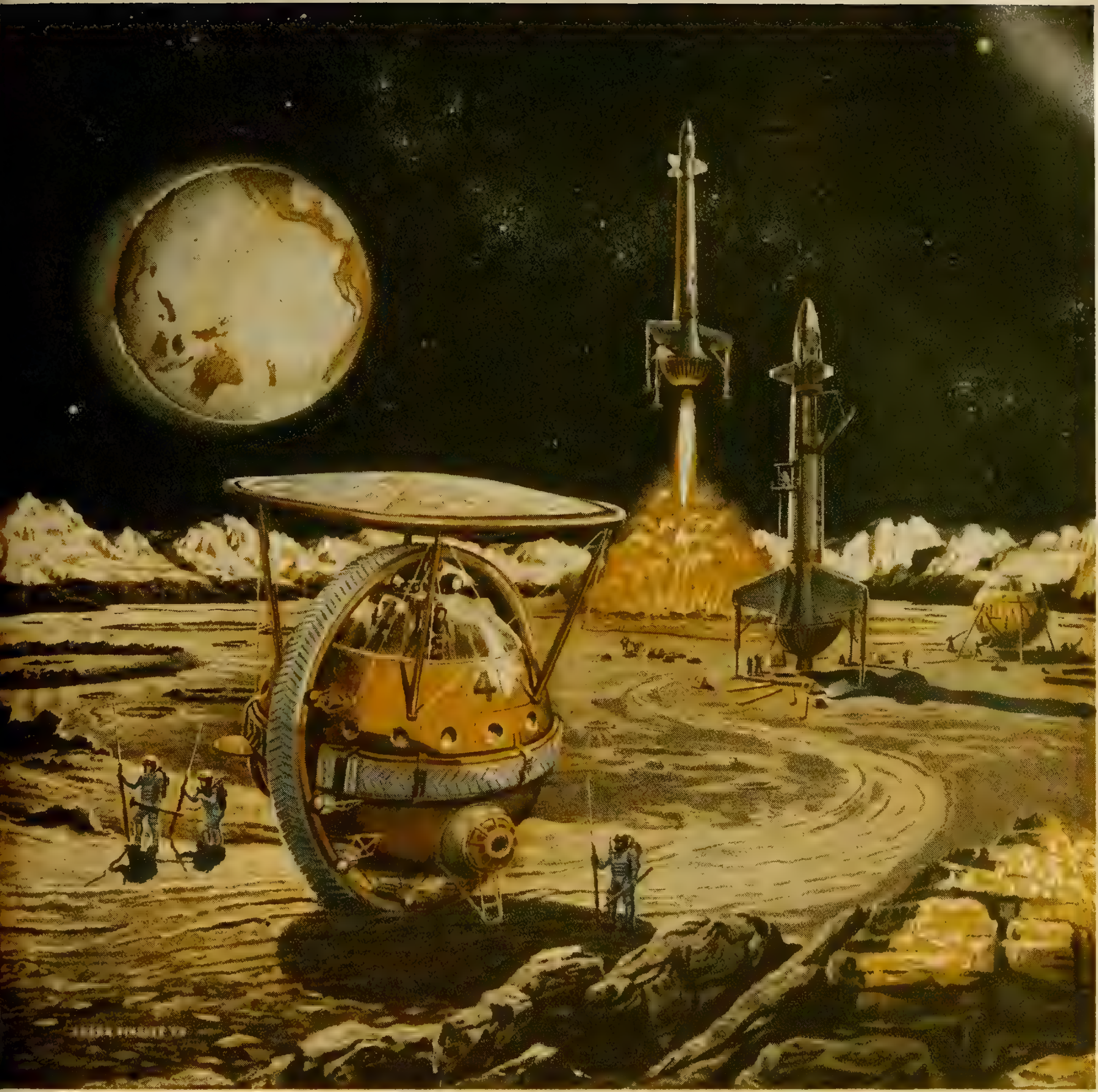
Missile components now comprise about 40% of D-P activity. Combinations of the division's in-production items will serve as a springboard to the systems.

One base of the systems designs will probably be the extensive line of subminiature, precision potentiometers now in production at a rate of 30,000 per month. Originally designed to meet D-P's own requirements in pick-off devices for gyro systems, these pots have turned into a prime dollar earner and much of the R&D work in systems has been carried by their sales.

The line is pretty well proven. Various types are in systems and subsystems for the *Explorer* satellites, *Titan, Atlas, Polaris, Jupiter, Bomarc, Talos,* and the forthcoming *Eagle*. Others are in use for missile systems by RCA, GE, Motorola, AC Spark Plug and Raytheon.

Second basic item for the new systems will be D-P's transducer line. Pointing out that few systems producers build their own transducers—and still fewer transducer producers are in the systems business—company officials believe a "from the ground up" combination of the two is mandatory to meet present or future requirements of missile precision and reliability.

Third base for the systems approach will be the division's experience in gyro design and production. Biggest production item for missile application are D-P's free gyros. These are in the GAM-77 *Hound Dog* autopilot and the *Polaris* test system. The company's



STEPS IN THE RACE TO OUTER SPACE

Lunar Unicycle

This 30-foot high Unicycle is designed for preliminary exploration of the Moon, once a base camp has been established. It's entirely constructed of inflated, rubberized fabric, with the exception of strengthening members, hatches and a few other items of equipment. Gyros stabilize and steer the vehicle; electric motors furnish the driving power.

Electricity for the motors and instrumentation comes from solar batteries mounted in the "parasol". The cleated, rotating wheel upon which the Unicycle travels is made of inflated tubes. A spare wheel, carried around the body, acts as a bumper in traversing narrow defiles. Built in two sections, these wheels are assembled by belt-lacing type fasteners.

The upper level, the navigating and communications deck, is ringed with recording and surveying instruments. Living quarters make up a middle deck and below is the hold with supplies, spacesuits, oxygen equipment and spare apparatus, needed for survival.

In the background, two of the expedition's ferry ships are seen; one landing, one unloading in the bright Earthlight.

Inertial navigation systems will play an increasing role in the exploration of outer space. ***ARMA*** is actively supporting the Air Force's program in long range missiles and is in the vanguard of the race to outer space. ***ARMA*** . . . Garden City, New York. A Division of American Bosch Arma Corporation.

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gyros were also used in the *Regulus II* pitch control system and in Lockheed's *X-17*. For other applications, D-P is turning out rate gyros at something between 300 and 500 units per month.

For systems application, some of the three base products may be off-the-shelf configurations. Other systems will require specialized development of one or more of the base components for integration into a system.

- **New gyros**—In the gyro areas, current developments include a cageable free gyro for the *Tartar* missile and vertical gyros for a drone guidance system—the latter is expected to have a high volume potential. An air-erected vertical gyro, some of which have been built by D-P before, is also under development. New design is expected to double the capabilities of older models.

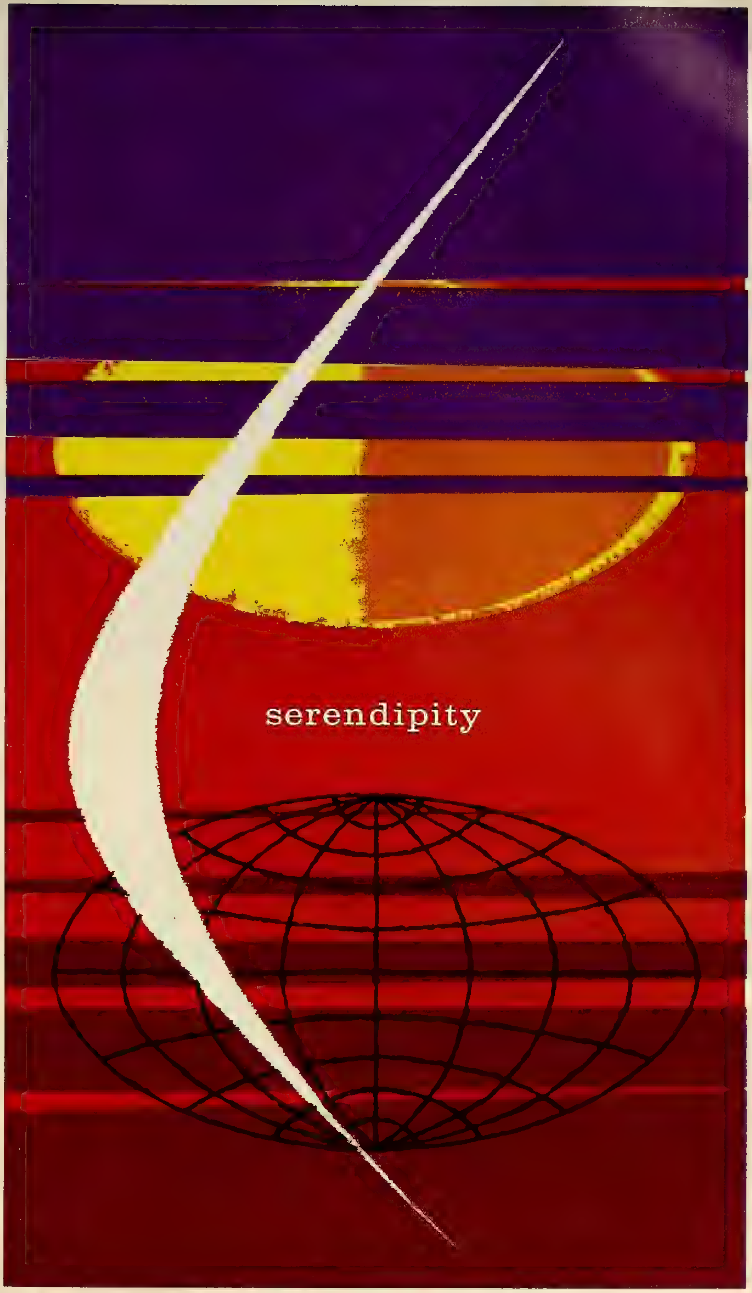
Many of the new gyros will have specific applications in themselves, but most are likely to be included in the company's systems designs.

- **Adaptable transducers**—There is much divisional enthusiasm for the null-balance pressure transducer, both as a single item and in systems.

The unit is designed to sense a pressure range of 31 to 0.80 in. Hg or an equivalent –1000 ft. to +80,000 ft. in pressure altitude. Sensitivity is said to be better than one ft. at sea level and 25 ft. at 80,000 ft., and basic design is adaptable to static, total or differential pressure applications. Instrument range can be increased or decreased with a respective compromise or improvement in sensitivity and accuracy. A shaft rotational position is provided as a function of sensed pressure value. Ports, electrical connectors and output shaft are available in standard hardware configurations.

The present model of the transducer may have limitations in pure ballistic missile applications. But it will probably find use in shorter range missiles or in supersonic aircraft when precise altitude may be absolutely required for airborne launches of certain missile systems now under development.

- **Future systems**—Future plans include an air data computer for flight control or a heading check. A possible missile application might take the form of a "rough check" system of in-flight position prior to activation of an arming circuit. Another system, similar in function but utilizing a different concept, is based on a unique accelerometer design. It could be used also for arming and fuzing of a weapon prior to or during re-entry, or for control adjustment in relation to velocity. This latter system is part of a military requirement that has not been completely met to date.



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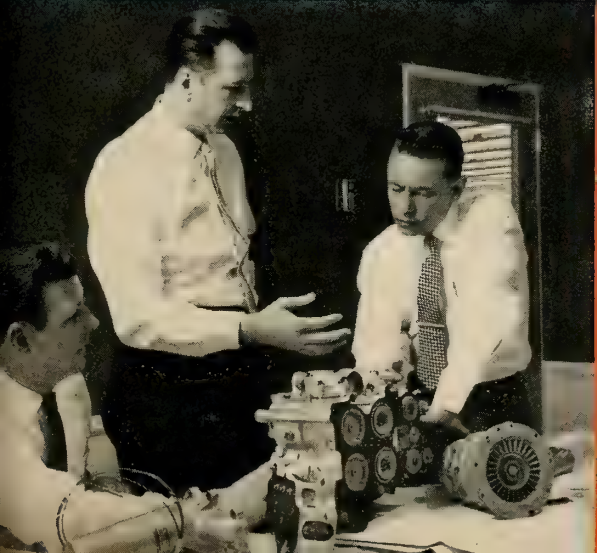
C & A Division activities range in scope from preliminary design through final production.

Professional engineers and scientists capable of making contributions in these and related areas are invited to investigate the employment opportunities at Marquardt. You will find a combination of significant, active projects and a lively interest in new ideas, creating an environment for professional growth. May I suggest you write Mr. Floyd Hargiss, Professional Personnel Department, 16552 Saticoy Street, Van Nuys, California?

Roy E. Marquardt, *President*



◀ C & A Division engineers made many contributions to the "state of the art" when they developed the fuel control system for the supersonic ramjet engine.

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GE's New Slave Mechanic Has 'Fingers'

'Handyman'—result of four-year development—will go to work in radioactive areas

SCHENECTADY, N. Y.—A machine representing the latest development in a progression of master-slave devices has been announced by General Electric Company. Its makers believe it to be the world's first electro-hydraulic servo manipulator having a bi-lateral (or force reflecting) feature and articulating "fingers." Spatial correspondence is provided between the master and slave units.

Taking its name from its principal function, "Handyman" is the result of nearly four years of development work by GE's General Engineering Laboratory here. Created for the company's Aircraft Nuclear Propulsion Department under contract with the U.S. Air Force and the Atomic Energy Commission, it will be used in dangerous radioactive areas for work on components for aircraft nuclear powerplants.

GE spokesmen said the research and development program required a close study of human anatomy. Ten basic motions were designed into each arm and hand: compounded, they make possible an almost infinite range of movement—all dictated by a master unit located outside the danger area. The operator feels what Handyman feels—and hears what it hears.

With his own arms and hands inside the master unit harness, the operator goes through motions desired of the manipulator. Handyman duplicates every movement simultaneously. Whatever the manipulator is handling, the operator feels too. For example, when Handyman clutches a hammer, the operator directing the master unit can close his fist only part way.

The portion or percentage of the forces encountered by the slave and reflected to the master varies according to the will of the operator. In most tasks, the operator feels but one-third the force exerted by the slave.

• **Vital statistics**—The system is composed of five units—master, slave, electronic console and two hydraulic pump units to circulate hydraulic fluid through master and slave units.

Company spokesmen also provided some vital statistics concerning Handyman's construction and operation. A few highlights:

1. The "hand" has five motions: two in the finger, two in the opposing thumb, and one at the wrist.
2. The forces encountered by the slave unit, or a portion of them, are reflected back to the master controls. The ratios of force reflected back to the operator can be adjusted in increments of 3 to 1, 5 to 1, 10 to 1, and 0.
3. Electrical signals are converted into hydraulic forces by electro-hydraulic servo valves. Servo valves and hydraulic actuators are located near the point of force demand. These juxtapositionings have reduced the number of hydraulic lines needed to distribute hydraulic power to each servo valve. Thus, the hydraulic lines are connected in a "Christmas tree" pattern of distribution rather than many parallel lines.

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Space Highlights Flight Meet

First World Congress of Flight attracts 5000 delegates, bringing industry and government together on problems

By Betty Oswald

LAS VEGAS—Opening of the First World Congress of Flight here was highlighted by the successful orbiting of a *Discoverer* satellite from Vandenberg Air Force Base as some 5000 delegates met to discuss problems inherent in the space race and their possible solutions.

The Congress in a sense represented the first attempt to weld into a consistent whole all of the decisive elements which start with aircraft and at present end with plans for spacecraft.

Delegates came from some 71 countries, many of which are behind the Iron Curtain, and there was representation from almost all elements of industry, the military and other agencies of government.

Meetings were well attended and serious. Behind the relaxed atmosphere at Las Vegas, there was genuine concern over problems posed by the arrival of the jet age and the future coming of the space age.

There were indications that many who had doubted the feasibility of the Congress were now convinced that a necessary start had been made in the battle to find a way by which industry and the government could talk together.

Meetings included a discussion of the problems of missile management, a Space Age Conference which dealt with such questions as the defense space program, the aims of space exploration, man in space and the relationship of space to foreign policy.

Industry briefings dealt with the *Argo* series of 2500-mile, Mach 20 low-cost research and development test vehicles, space applications for infrared techniques, astroinertial navigation, range instrumentation for space probes and a wide variety of other questions which must be solved before the space age becomes reality.

A session was devoted to international research efforts including the work of the Air Force Office of Scientific Research and the project activities of ARDC's European office. Recognizing that the entry into space will involve major changes in current education patterns, one session was devoted to aerospace education, with educators from many foreign countries attending the meetings.

• **Old and New**—Exhibits covered not only existing hardware but, in some cases, the dreams of scientists and engineers, many of which were 10 or more years in the future. These included a mockup of the *Mercury* space capsule, in which man is expected to orbit the earth within two years, and a mockup of the *X-15* rocket research craft, which will provide answers to many of the problems which the *Mercury* pilot will face. Hardware included *Atlas, Thor-Able,* most of the smaller tactical missiles now in or soon to be in inventory, and a mockup of the *Genie* AAM utilizing a nuclear warhead.

Notwithstanding the futuristic tone of the Space Age exhibits, there was no escaping the wedding of the old and the new. World War I airplanes flying over the same field as missile-carrying, supersonic jet aircraft set the same pattern of extremes as the World War I invention, the tube mortar, being used in the Project *Mercury* capsule to fire a drogue parachute.

Distant-future concepts included Avco's ADOS, Astro-nautical Defensive-Offensive System, a method of insuring peaceful space travel through the use of one and two-man space ships with nuclear weapons and various other types of armament. The *Ados* vehicle greatly resembles a flying saucer with a tail, uses electronic detecting and computing techniques still to be developed.

Other exhibits dealt with advanced communications and electronics equipment for space craft, and new propulsion hardware. Product improvement permitting pilot training in spacecraft was suggested in presentations of a new supersonic jet trainer, the Northrop T-38.

Steering Jets by Bendix Stabilize *Discoverer II*

DETROIT—*Discoverer II* is stabilized in its polar orbit by a set of steering jets.

The mechanism, developed by Bendix Aviation Corp.'s Research Laboratories Division, may lead to development of an observation satellite. All previous satellites tumbled, making continuous aiming of a camera impossible.

In the steering jets, gas is discharged in response to electrical signals from *Discoverer's* inertial reference package, providing desired thrust up to 20 pounds.

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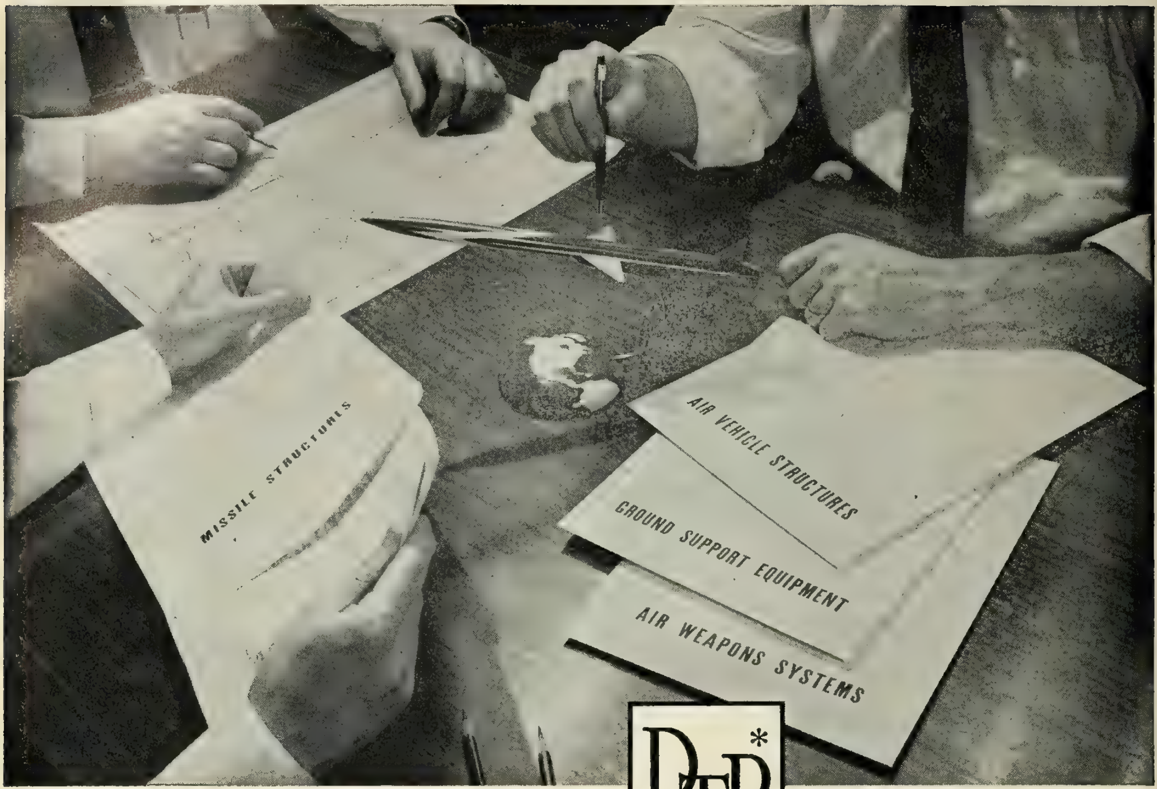

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more about the missile week

Negotiations looking to a merger of Thiokol and Marquardt started this week. Odds favor the merger of the two big propultion companies.

For return to earth, *Mercury* capsule will be equipped with mortar-fired drogue parachute to stabilize the vehicle at 68,000 feet. Drogue will be jettisoned at 10,000 feet when the main 'chute is activated. This provides impact velocity of 30 ft./sec. at 5000 ft. A reserve landing system, completely independent and mechanical, is available to the test pilot.

Mock-up of Avco's Astronautical Defensive-Offensive System (ADOS) for Air Force (M/R April 13) looks like a flying saucer with a protruding boom on which a nuclear weapon is mounted. Futuristic one-man spacecraft is designed for deep-space missions. Ring of defense rockets revolves around man-carrying sphere, enabling rockets to be fired in any direction. Nuclear weapon is placed on boom to protect pilot and is for targets too big for rocket missiles to handle.

High-vacuum research indicates to ABMA's Dr. Karl J. Pschera that "only inorganic materials" can survive exposure in interplanetary space. Organic materials such as rubber and plastics, he says, vaporize or undergo molecular distillation in a vacuum. More research may expose new reliability problems involving metal fatigue and creep encountered in space conditions.

New missile alloy—EK31XA—is reported to have double the strength at 500°F of any known light metal. Dow Chemical Co., developer, says it consists of magnesium, didymium and zirconium.

"Adult" *Atlas* first operational series test got off to shaky start April 14. The ICBM exploded about 1000 ft. above its Cape Canaveral launch pad on what had been programmed as a 5000-mile flight.

Jupiter IRBM is ready for deployment with troops. Chrysler Corp. says recent tactical weapons test demonstrated "beyond question" that production line hardware is ready for use.

Newly-synthesized tetracoordinate phosphinoborine molecule (mw 12,500) is hope of American Potash & Chemical Corp. to develop heat-stable plastics withstanding temperatures up to 400°C.

Air Force is asking Congress in its 1960 budget for $109.8 million in new obligational authority for *Dyna-Soar*—$73 million in expenditures to develop the manned-glide vehicle.

Maj. Gen. J. B. Medaris gives this breakdown of spending by his Army Ordnance Missile Command: .25% for operation of headquarters; 5% for systems management and technical supervision, including testing and range management; 5% for research, engineering, fabrication and technical effort to maintain in-house capability for directing industrial contractors; and 89.75% with private contractor organizations.

Polaris solid fuel consistency will be checked with 25-million-volt betatron, which cuts process time to minutes. Navy's Allegany Ballistics Laboratory, Cumberland, Md., is getting the $112,325 Allis-Chalmers X-ray machine this summer.

Detection of micron-sized particles in missile fuels is reported by Grumman Aircraft and Sperry Products with a new ultrasonic device. System works as fuel is being pumped from truck or tank to rocket and will automatically cut off flow on finding contaminants. Has worked successfully on checking fluids from –298°F to 1050°F.

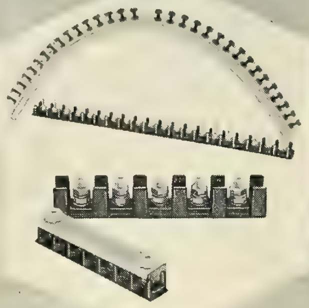
Expansions: Sperry Gyroscope Co. has acquired a 52,000-square-foot building at Syosset, L.I., to produce *Polaris* ship's inertial navigation systems (SINS) and navigation data assimilation centers (NAVDAC's). Dynatronics, Inc., in the midst of an enlargement program, expects to move into a new 20,000-square-foot plant at Sanford, Fla., in June. Republic Aviation is erecting a $14 million, 120,000-square-foot R&D center at Farmingdale, N.Y., for missile/space research. It will be ready early next year.

Look for negotiation of a contract to develop *Vega* second stage, which will use LOX and kerosene-fueled existing power units. Similar in concept to *Centaur*, *Vega* is to be put into space with an *Atlas* booster.

Pentagon reveals that a single MB-1 *Genie* nuclear warhead costs $243,000; rocket itself costs $7000. *Genie* is carried by fighters of the North American Defense Command.

Ground will be broken at Lowry AFB, Denver, for second $40 million *Titan* ICBM base. This brings to four the number of hard *Titan* bases that have been announced. Seven *Atlas* bases are in various stages of construction.

olympic
terminal
strips



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propulsion engineering

Four ceramic nozzle materials with the longest functional lifetimes have been determined at Battelle Memorial Institute. They are silicon carbide, zirconium boride, beryllia, and a silicon-impregnated graphite surface. The functional life varies from 60 to 107 seconds on an engine burning hydrogen and oxygen at 4500°F. Among the shortest-lived materials are graphite coated with zirconium carbide, boron carbide, and hafnium carbide—with lives of about 15 seconds. Battelle scientists observe significant differences in functional life between ceramics of similar composition.

High-purity thorium for basic studies of the metal's properties can be prepared by a new process to be announced early next month during the Philadelphia meeting of the Electrochemical Society. High-grade thorium oxide is reduced by calcium in an inert atmosphere at 1742°F. Some calcium chloride must be present. The resulting thorium is a powder. The technique was developed by C. I. Whitman, Sylvania-Corning Nuclear Corp.; N. Fuhrman, now with Lansdale Tube Co., and R. B. Holden, currently with Olin Mathieson Chemical.

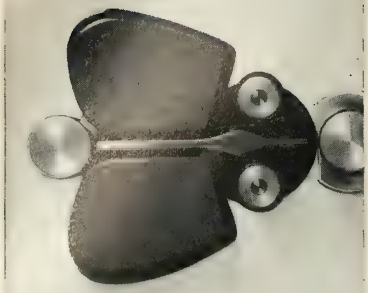
Super-pure aluminum for property studies also will be described to the electrochemists. R. R. Haberecht, P. R. Mallory & Co., starts with 99.99% pure aluminum prepared by zone refining. He treats this to vacuum melting to achieve aluminum with metallic impurities of only 1-3 ppm, and less than 5 ppm of carbon. He says this super-pure product shows marked improvement in corrosion resistance over the 99.99% pure aluminum.

Aluminum is revealing more about itself all the time, thanks to increased research and increasing availability of pure forms for fundamental study. A new refractory crucible, aluminum nitride, developed especially to aid aluminum research, has been described to the American Ceramic Society by George Long and L. M. Foster, Aluminum Company of America. It is the only material yet discovered that is not attacked by aluminum under investigation in a temperature range of 3282°-3632°F. It shows good ceramic properties and has been pressed into heretofore unavailable labware.

Metal-free phthalocyanine is a superior solid lubricant in the 1000°F area, a Battelle Institute team reports. A project conducted for Fairchild Engine and Airplane Corp. showed that other members of the phthalocyanine family also are good high-temperature solid lubes. In testing various proposed lubes, the group killed two birds with one stone by using various materials also under study for the balls in the wear machine. Most promising for high-temperature sliding systems are AISI Type M-1 tool steel and titanium carbide-nickel-molybdenum cermet.

Lubrication research in Germany is taking the form of molybdenum sulfide studies. German chemists report in *Chemiker-Zeitung* that moly-sulfide's layer structure recommends it to high and low temperature and pressure uses. It will also find "application in unusual atmospheric conditions."

Czechoslovakian metallurgy is rapidly becoming an Iron Curtain showcase for scientific progress. Recent reports include a detailed analysis of the function of temperature change on crack distribution in cooling castings, and development of more durable coatings for metal molds. Frantisek Havlicek reports in *Slevarenstvi* (Vol. 6, No. 9) that rectangular, square, and even elliptic cross-sections resist cracking better than round cross-sections. Nonhomogeneous temperature distribution is a function of casting shape, Havlicek says. Alois Sustek reports in the same issue the development of a new series of adhesion and cohesion coatings for metal molds. They are said to be superior to previous coatings in durability, among other things. The new Czech coatings are good for 700-800 pourings, whereas the older coatings broke down after 350-450 pourings.



AMPEX increases signal/noise ratio

A real challenge to magnetic-tape sensitivity comes with frequency-multiplexed data. It is here that the tape's signal-to-noise ratio can mean success or failure. The high levels of occasional combined peaks can build up modulation noise between channels and seriously affect signal output.

Ampex meets this challenge by minimizing tape noise. Painstaking care in coating composition and thickness, plus the exclusive Ferro-Sheen process, gives Ampex Instrumentation Tape a completely uniform, hard, smooth surface that tangibly increases its dynamic range.

Ampex Instrumentation Tape offers other critical improvements, too. A high degree of linearity in its anhysteretic induction output greatly reduces signal distortion, further enhancing the signal-to-noise ratio.

Ampex Instrumentation Tape is available on hubs, NAB-type or die-cast magnesium-alloy Precision Reels. Widths of ¼", ½" and 1" are standard on either Mylar* or acetate base, in the following lengths, reel diameters, and base thicknesses:

AMPEX STANDARD TAPE LENGTHS (feet)

REEL DIAMETER	BASE THICKNESS (mils) 1.0	1.5
7"	1800	1250
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14"	7200	5000

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For complete specifications or additional tape literature, write

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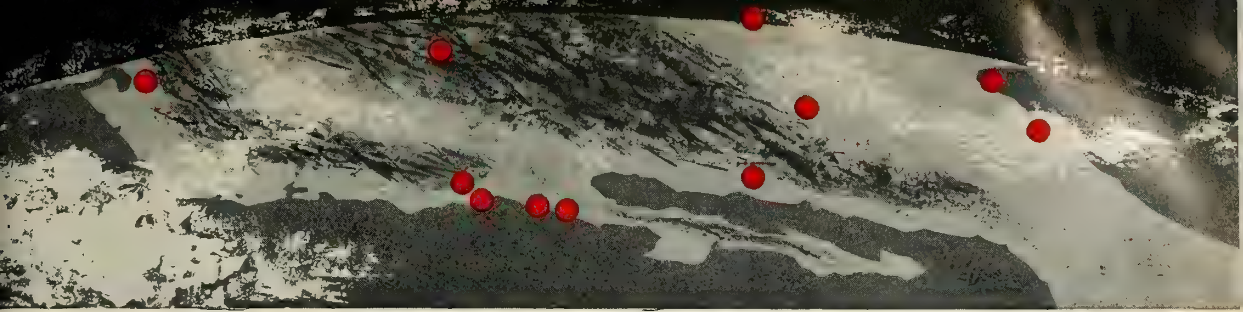
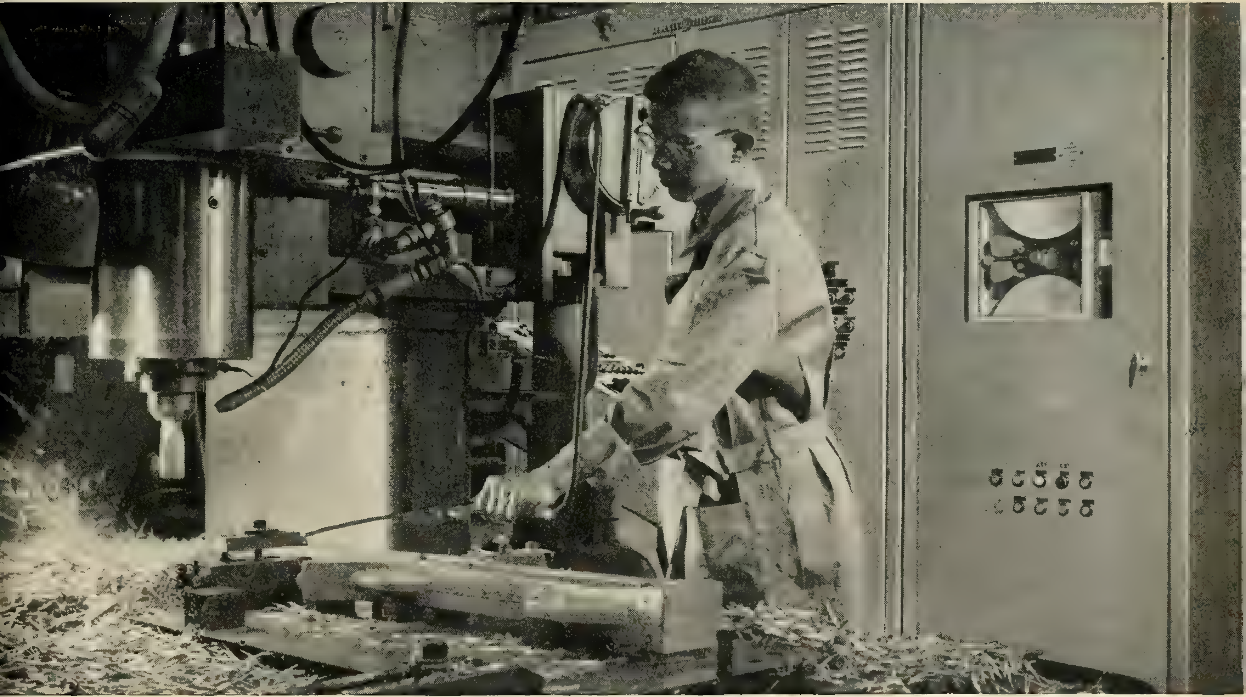


Where the shape of things to come



is programmed by AMPEX tape recorders

The profiler above is shaping parts for new Lockheed Electras. Exact tool positions are being defined by command signals—as many as 200 per second—from the Ampex FR-100 in the control system to the right of the machine.

The accuracy of such a milling operation increases with the number of points defined per inch of tool motion. One reel of magnetic tape defines millions of points, programming up to 1½ hours of continuous machine operation. Recycling a tape loop will program an entire run of identical work-pieces.

Shaping parts by command signals from Ampex-equipped automatic control systems is now routine production operation at such places as Lockheed in Burbank, Martin at Denver, Rohr at Chula Vista, Convair at Ft. Worth and San Diego, and Giddings & Lewis at Fond Du Lac, to mention only a few.

Even though punched cards and paper tape are still proving adequate for many of today's less-sophisticated automatic control installations, systems engineers are increasingly interested in the superior speed and data-handling advantages of magnetic tape. An Ampex FR-300, for instance, can extract a short burst of digital information equal to that on an entire punched card in less than 4 milliseconds, including start and stop.

In configurations like the one illustrated, the advanced Ampex FR-100A, with its 14 tracks on 1-inch tape, has ample reserve for extra functions. Six tracks may be used for tool-position coordinates; others for start, stop, coolant, or even voice instructions.

Whether you believe the future of automatic control lies in point-to-point positioning, continuous-path control, or both—Ampex magnetic tape recorders have built-in reserve capabilities which make them worthy of consideration as a component for any control system designed for tomorrow's needs.

First in magnetic tape instrumentation

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DATA
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SPECIALISTS

The Techniques of High Speed Data Processing Offer A Big Future For You!

A missile comes "of age"—reaches operational status—as a result of many influences. Vital among these influences is the rapid incorporation in the test vehicle of modifications required by evaluation of flight performances. The faster these modifications are made, tested, and become incorporated in the design, the faster the vehicle is declared operational.

The completion of this cycle is dependent too upon the speed with which vast amounts of test data can be reduced, analyzed, evaluated, and reported to the military and to the cognizant weapon systems contractors.

So, with the advent of missiles has come a revolution in data processing techniques—a revolution in which the Engineering Services Division of Telecomputing Corporation has been highly successful in greatly reducing the elapsed time for complete processing of missile flight test data.

This is an invitation to join the data processing specialists who comprise the Engineering Services staff—a staff which establishes the state-of-the-art in data processing techniques and methods as we go about our job of computing the performance of missiles under test at the White Sands Missile Range.

Join us and work with high speed digital computers and other modern data processing squipment in reducing the test data from scientific data measuring systems such as, cinetheodolites, electronic measuring systems, precision optics, and telemetering systems.

Join us—and grow with us—as our advanced processing techniques are employed in this fascinating field of missile flight testing so important to our national defense effort.

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New Mexico

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soviet affairs

by Dr. Albert Parry

As we watch carefully what the Soviet press says about U.S. rocketry, missilery, and electronics we may discover just what (precisely or approximately) they lack but would like to have. Sometimes such Russian writings may indicate in which fields or categories the Soviets are behind; often they show that Moscow is on a par with us but means to forge ahead. On occasion the implication is: "Those darned Americans are catching up with the Soviets. We must not let them."

What, for instance, is the United States doing to switch from liquid to solid fuels in rocket engines? Early in March *Sovetskaya Aviatsia* ran a special article on "speed-up work to improve solid-fuel rocket engines," now being done not alone by U.S. experts but also by "the military specialists of other NATO countries." The author of the survey, Maj. Y. Tikhomirov of the Soviet engineering troops, begins with the gleeful assertion that Americans and their allies have been turned toward solid fuels by "the large number of failures in launching liquid-fueled American rockets."

In text and diagram, Tikhomirov explains the principles of solid-fuel rockets. He goes on to say that U.S. and other NATO experts "plan to apply solid-fuel engines to nearly all kinds of rocket systems," and that "no expense is spared" to this end. The implication, quite possibly, is: Shouldn't we, the Soviets, do the same? Or, if the Soviets are doing very well in this field of solid fuels, shouldn't the Red effort be stepped up yet further?

Our *Argus* experiment had been "guessed" (if not otherwise learned) by Soviet scientists shortly before we made it public. On March 8, in *Izvestia,* Professors I. S. Shklovsky and V. I. Krasovsky in a joint interview ventured their belief that the United States was "testing their atomic weapons, with explosions at great heights of 100 to 200 kilometers." They went on to speculate on the general aims of such experiments pretty accurately. A wishful note was quite evident: Why shouldn't Russia do something of this type?

Outright admissions of Russian gaps include the recent statement by Dr. Alla G. Masevich, the well-known, personable, 40-year-old Russian astronomer, made to a reporter from the Moscow *Ogoniok* (March 8) to the effect that on her trip to the United States a few months ago she was shown "an automatic electronic machine to measure stars," the like of which she had not seen before. She said that an American professor demonstrated it to her at the Naval Observatory in Washington. "I regretted," she added significantly, "that we in the Soviet Union do not have any such machine."

Last but not least, on Feb. 19, one K. Gil'zin in *Literaturnaya Gazeta* described the "parts of a solar power installation meant for possible exploitation on the moon," as exhibited in Washington by Westinghouse and explained in detail by Dr. Peter Castruccio. The Soviet writer concedes that this idea is rather good, but he attacks Dr. Castruccio for "joining the American Professor (S. Fred) Singer in the latter's proposal to transform the moon into a launching site for atomic weapons." (Gil'zin misinterprets, perhaps deliberately, Prof. Singer's 1957 paper, in which he merely worked out the physical effects of an explosion on the moon.)

The Russian writer's wrath is aroused by Dr. Castruccio's articles in M/R on the "strategic advantages of lunar bases" as military fortresses of the future. Comrade Gil'zin entitles his article, "For Shame, Doctor Castruccio!" He cries shame also on M/R for publishing Dr. Castruccio's writings.

However, my impression is that these cries of indignation are but camouflage, and that interest in the U.S. idea of solar power installations on the moon is the main point of Gil'zin's outburst.

U. S. ARMY ANTI-MISSILE MISSILE

The man:

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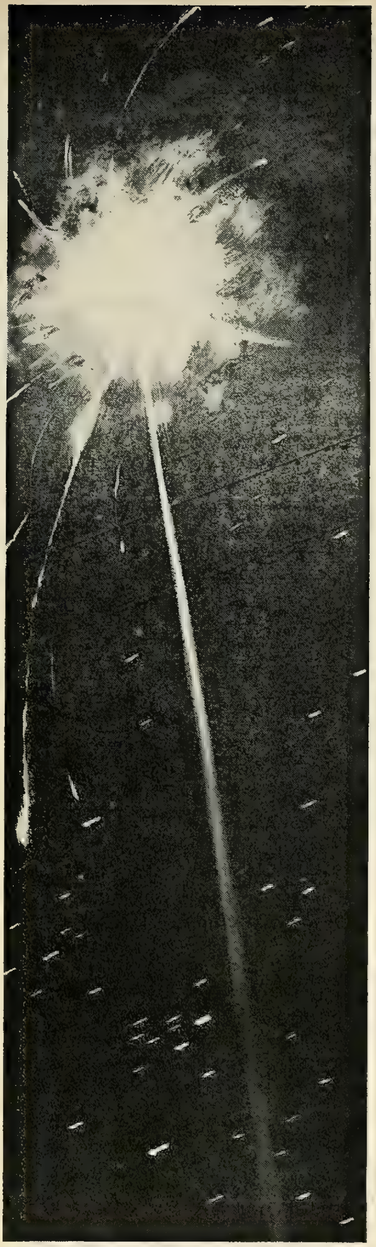
When *Zeus* goes on active duty, it will follow Douglas *Nike Ajax* and *Hercules* missiles into service with the North American Air Defense Command. And it will be maintained by Army personnel assisted by Douglas field service men who have extensive experience in the *Nike* program.



The mission:

. . . anti-missile defense. *Zeus* will roar out from emplacements around cities and industrial and military areas to intercept approaching enemy ICBM's . . . or bombers.

CLASSIFIED

The missile:

. . . *Nike Zeus* is being developed by Douglas under a Western Electric-Bell Telephone program. System will include electronic detection gear to pick up enemy ICBM's at extreme range and then guide *Zeus* out to destroy them. Vital statistics: CLASSIFIED.

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Transistors vs. Tubes

To the Editor:

Your article of March 16 on "Transistors vs. Tubes" requires a few comments . . .

It is all too easy to say that "radiation" harms transistors and let it go at that. A first step should be to assess the rest of the environment which accompanies this "radiation," its effects on the system, and the comparable radiation damage. It is of little use to replace a transistor by a less susceptible vacuum tube only to find that accompanying overpressure and thermal effects are the dominating destructive agents coincident with the radiation level against which one is now protected.

Now as to some particulars. I do not know the difference between primary and secondary fission products; however, the penetrating power of these products, even at their original velocity when they emerge from a detonation, is insufficient to pierce any missile, rocket, or aircraft skin, so I do not readily see how they can effect a transistorized system.

The accompanying gamma radiation from such a cloud, even in its early stages, is many orders of magnitude below that which will degrade semiconductors, especially since gamma radiation causes very little permanent damage and, at the radiation levels encountered in a cloud, only the barest minimum of temporary changes.

As of the effects of "high" neutron fluxes on transistors, it cannot be overemphasized that in the context of relationship to missiles, as differentiated from the completely different problem encountered with nuclear propulsion aircraft, one should be exceedingly careful of defining the limits of the possible and probable environment before making a sufficiently broad condemnation.

It should furthermore be pointed out that even vacuum tubes and their associated circuitry are subject to sizeable effects at radiation levels which are both possible and probable in a number of applications.

P. H. Haas, Chief,
Nuclear Vulnerability Branch,
Diamond Ordnance
Fuze Laboratories,
Washington, D.C.

It was not the intention of the article to take sides in the transistor vs. tube controversy. Our purpose was to call attention to a matter of vital concern to the industry and point out that, in the opinion of many observers, more research is needed concerning the effects of radiation on both tubes and solid state devices. M/R plans to publish in the near future several articles in which both sides will be allowed to give their views.

Not Air-Launched?

To the Editor:

I am rather disturbed about one, and possibly two, mistakes in your March 23, 1959 issue of M/R.

In the Washington Countdown section, page 15, under the heading of "the mystery firing . . ." I was sorry to see the word "McDonnell" misspelled "McDonald." But I was glad to see that it was spelled correctly on page 23, right hand column.

2. In the same article the statement was made that the two-stage missile that McDonnell fired was an "Air-launched" missile. I have very strong reason to believe that this statement is incorrect. I believe that it was a "ground-handled" missile. Would you please straighten this out?

Herbert E. Wodtke
3530 A Pennsylvania Avenue
St. Louis 18, Missouri

We regret the misspelling of McDonnell too. Our sources tell us that the missile launched was McDonnell's version in the ALBM competition. However, DOD will not comment.

target bearing 095°
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speed—
270,000
m.p.h.!

Guided missiles of the future are *on our scopes today*—thanks to the agile brain of an amazing new ECM Simulator developed for the Air Force by Hallicrafters QRC.*
Designed for advanced study of jamming, deception and countermeasures techniques, the device furnishes to the PPI scope—*via the radar's own antenna*—exact simulations of moving targets, and jamming, in infinite variation.
Programming may be generated according to predetermined plan, or targets may be controlled manually. Speeds as fantastic as *270,000 m.p.h.*, as well as radical directional changes, now can be simulated for planning tomorrow's counter-measures.
ECM Simulator is another example of electronic design leadership that has made Hallicrafters a prime mover of key military projects for over 25 years.

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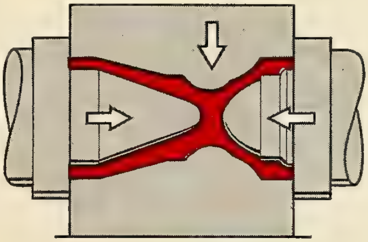
A BETTER NOZZLE MEANS A BETTER MISSILE

Nozzles for guided missiles are an important factor in performance and, of course, in cost. In the end result during their short-span service, they must produce proper thrust without disintegrating. In early production, despite their simple symmetrical shapes, they posed many knotty problems. Special alloys, thin sections, and close tolerances spelled trouble. So did their expendability, as always making costs a concern.

Today, after many years' production, we have delivered a staggering number of these problem pieces. The secret of our success has been our own unique Cameron forging processes which have extended the scope of ferrous forgings far beyond traditional restrictions in shape, size and quality. Elimination of welds along with better grain structure, internal as well as external curvatures, and considerable machining economy have made these forgings increasingly popular.



Our forgings are available as forged, rough machined, or finished machined, ready to save money in any phase of your operations. If you have a forging problem in components ranging from a few pounds to 8000 pounds, especially something for extreme service (high stress, high temperatures, etc.) we may have the answer. Special alloys are no problem because we produce our own steel with the most modern controls and tests from melt shop to delivery dock. Just call, write, or come by . . .

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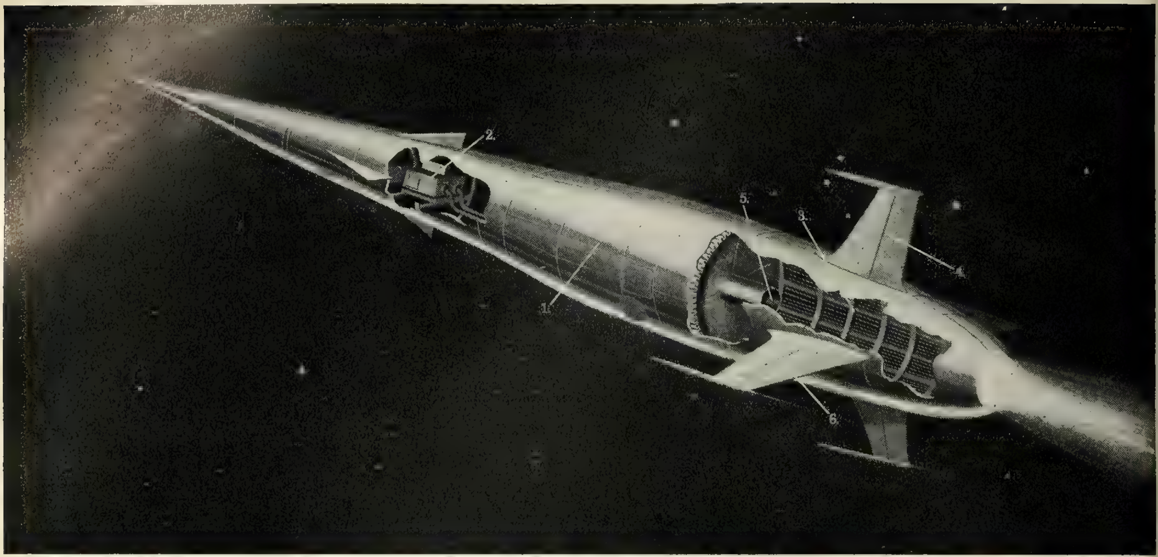
DOW | **MAGNESIUM**



Design a missile with light, strong magnesium alloys

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2. **DEEP DRAWN HOUSINGS AND CASTINGS for guidance and other instrumentation.**
3. **CASTINGS AND EXTRUSIONS for body frame.**
4. **CASTINGS AND EXTRUSIONS for fin and wing construction.**
5. **ROUND EXTRUDED TUBING for integral body sections.**
6. **SHEET for external skins of fins, rudders and wings.**

THERMAL PROPERTIES OF LIGHTWEIGHT MAGNESIUM

offer advantages to missile men

Most engineers are aware of the advantages available to them when they combine magnesium's light weight with its good mechanical properties at elevated temperatures up to 800°F. There are, however, other advantages such as thermal properties that are less well known. They, too, can be of real value to missile designers. In many cases they will open new areas in design previously considered closed to magnesium.

Let's consider one of these, magnesium's high specific heat and its relationship to missiles. This can mean lower temperatures for given flight conditions. As a result magnesium can be used under very severe flight conditions for short time applications. (See Fig. 2.) This permits the use of magnesium in high speed missiles which are exposed to heat generating atmosphere for only a matter of a few seconds. With magnesium acting as a heat sink it can result in reducing environmental temperature for electronic instruments.

Magnesium offers other thermal properties that are of value in aircraft and missile design. For example, the thermal diffusivity of magnesium-thorium alloys $\left\{\frac{\text{Thermal conductivity}}{\text{Specific heat x density}}\right\}$ is high and remains fairly constant over a large temperature spread. Between 68° and 900°F. the thermal diffusivity of these alloys is in the range of 0.57 and 0.75 cm.^{2}/sec. (2.2 and 2.9 ft.^{2}/hr.)

For more complete data send for Bulletin 141-187 "Magnesium Alloys for Elevated Temperature Use." Contact your nearest Dow Sales Office or write to THE DOW CHEMICAL COMPANY, Midland, Michigan, Department 1300CL4-20.

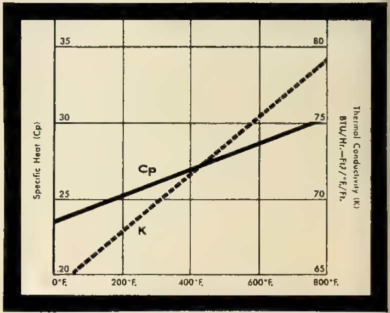

Fig. 1. Specific Heat and Thermal Conductivity of Magnesium-Thorium alloys.

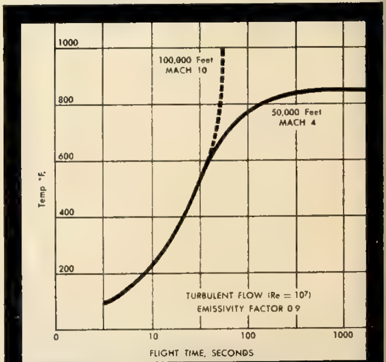

Fig. 2. Effect of Structure Temperature and Flight Time on Mg-Th Sheet Alloys at Mach 4 and 50,000 Feet and Mach 10 and 100,000 Feet.

THE DOW CHEMICAL COMPANY • MIDLAND, MICHIGAN

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. . . TAX WRITE-OFFS

(Continued from page 19)

On the other hand, NASA and DOD are for it because they can "save" money. In many instances DOD has had to spend appropriations for brick-and-mortar and specialized equipment which industry wouldn't—or couldn't afford to—put up without a tax incentive.

NASA apparently has adopted a policy of buying from commercial sources rather than building its own facilities. An official told M/R continuation of rapid tax write-offs therefore becomes of "import to national security" by aiding the space program.

A bill extending the Byrd law for four years—and including NASA contractors—has been introduced by Rep. Richard M. Simpson (R-Pa.), ranking GOP member of the House Ways and Means Committee. No hearings have been scheduled on this measure (HR 5326). Committee aides say there may not be any.

- **Old bugaboo**—Conceivably, inclusion of NASA could rekindle an old Congressional controversy which brought about the Byrd law. For the space agency intends to spend billions of dollars in the next few years. And most of it would be eligible for fast write-off.

Such magnitude would approach the hey-day of the program, which was started in 1950 during the Korean War to help mobilize defense industries. In the 1950-57 period, OCDM granted rapid amortization certificates on $23 billion worth of expenditures by some 220 different industries.

The shut-off came amid charges that the privilege was being abused. One sore point: certification could be granted then whether or not an applicant held a defense contract. Some lawmakers felt this was handing out five-year tax reductions.

Spokesmen for industry countered that it was only a deferment in tax payments and no revenue was "lost" by the Treasury in the long run. Furthermore, they pointed out that during an inflationary spiral, long-term amortization was unrealistic on specialized facilities which depreciated rapidly and whose replacement costs were steadily mounting.

- **Present status**—Since 1955, when the rocket program began cranking up, OCDM estimates that a total of approximately $350 million in certification has been allowed firms directly connected with the missile/space industry. Smallness of this figure attests to the stringency of the program since 1957, although billions are being spent on missile development.

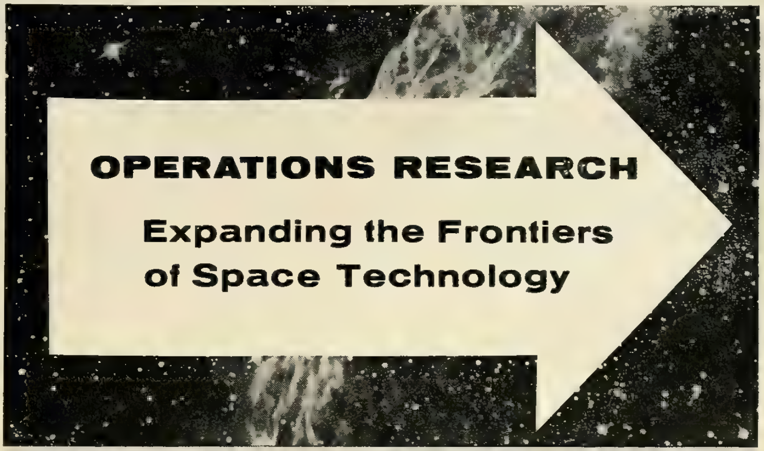
About 175 applications for certificates are pending before the OCDM. Some of these date back "a year or more," the agency says. One official concedes the delay "could be a factor" in holding up the construction of facilities valuable to the missile/space effort. Reasons for the hold-up:

All applications must be processed through several agencies of the DOD and AEC.

No certificates were issued from August, 1957, through June 1958, while new regulations geared to the Byrd law were being written.

An M/R survey indicates that in the past 10 months few companies have derived very substantial tax deferment to provide money for extra research facilities now, nor in the immediate future.

Unless Congress grants an extension beyond Dec. 31, even this rivulet will dry up. In this event, several industry experts believe, more money must be found somewhere to pump into basic research—or the entire U.S. space effort will suffer.



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west coast industry

by Fred S. Hunter

The debate over how space money should be spent seems to be warming up.

The other day, Dr. A. R. Hibbs, Jet Propulsion Laboratory's outspoken chief research analyst, declared U.S. preoccupation with military aspects of space is "out of all proportion to any realistic application." Hibbs said he doubted that Russia would shudder if American troops planted a flag on the moon. "They know the moon is two days travel away while their ICBM's take only 30 minutes to reach our cities."

In discussing realities of space exploration before an erudite audience at CalTech, Dr. Simon Ramo, executive vice president, and Dr. Ralph P. Johnson, vice president and general manager, Thompson Ramo Wooldridge, had this to say: "If the refinement of the capability for effecting mass destruction by quick and irresistible means at intercontinental distances comes into competition with the expansion of a capability for exploring space—and the two lines of development are already diverging—we can hardly doubt that the projects for military ends will be given priority."

To a financial audience, Dan Kimball, Aerojet-General president, put it this way: "We can't make any valid distinction between 'useful' military hardware and 'useless' exploration of space. Both of them take the same kind of power, the same kind of vehicle and the same kind of guidance. Just as the airplane that could photograph could also bomb, so the satellite which can spy in orbit can be used for any military purpose we or the Russians desire. Let's not fool ourselves about that!"

New plant Hoffman Electronics is building at El Monte, Calif., for its semiconductor division, plus the output of the present Egansston, Ill., plant which is to continue, will up this company's production of solar energy converters to half a million monthly. Hoffman's accomplishments in increasing efficiency of solar energy cells from 3% to 9% and 10%, and in developing new methods to manufacture them in production quantities, have made the solar cell the lowest weight power source for space vehicles. Hoffman forecasts that the volume of its semiconductor division—$6 million in 1958—will reach $30 million by 1965 as industry is made aware of the usefulness of these wonder products.

Lockheed may follow example of Hughes, Aeronutronics and others and join the movement to Orange County for a permanent abode for its new electronics division. It is looking for a site to build. It is presently located temporarily at Maywood in the old feeder plant originally purchased by Lockheed for production of subassemblies for the Super Constellation. Lockheed also made a few early Electra parts here, but until the electronics division moved in the facility had been idle for about nine months.

Marquardt had already phased in production on the new model RJ43-11 ramjet engine for the longer-range *Bomarc B* when the Air Force's $300-million order to Boeing was announced. Generally, frames run ahead of engines in this business, but in the *Bomarc* development it has been the other way around. The Dash II engine is produced at Marquardt's Ogden plant, but has to be shipped to Van Nuys for testing. The new testing facility being built in Utah will be completed in September or October, but won't be ready for actual operation until the first of next year. It will take a little time to test the test facility.

S. K. Hoffman, general manager of Rocketdyne, says eventually missiles will take off and return to the launching site in a vertical position, be checked, refueled and launched again on space missions.

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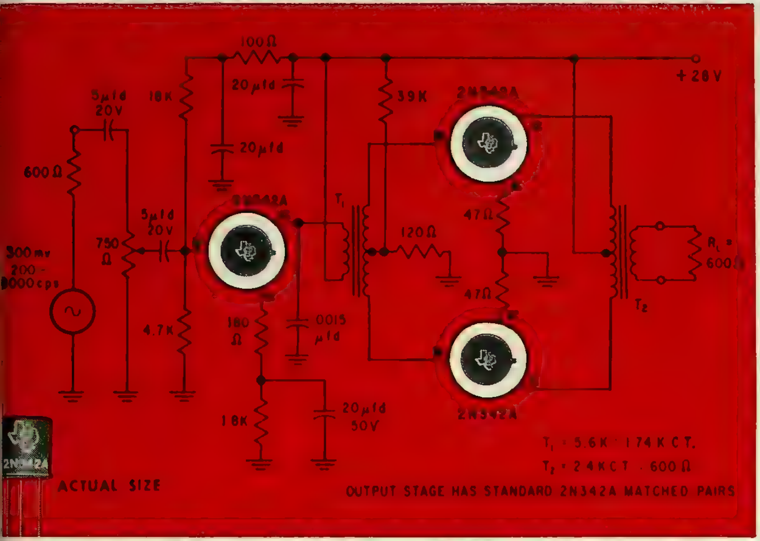
TI Silicon Transistor Application Note

TRANSISTORIZED INTERCOM EXCEEDS MIL-E-5272B SPECS



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Less than 3-db gain variation @ -55°C and 100°C compared to 25°C measurement

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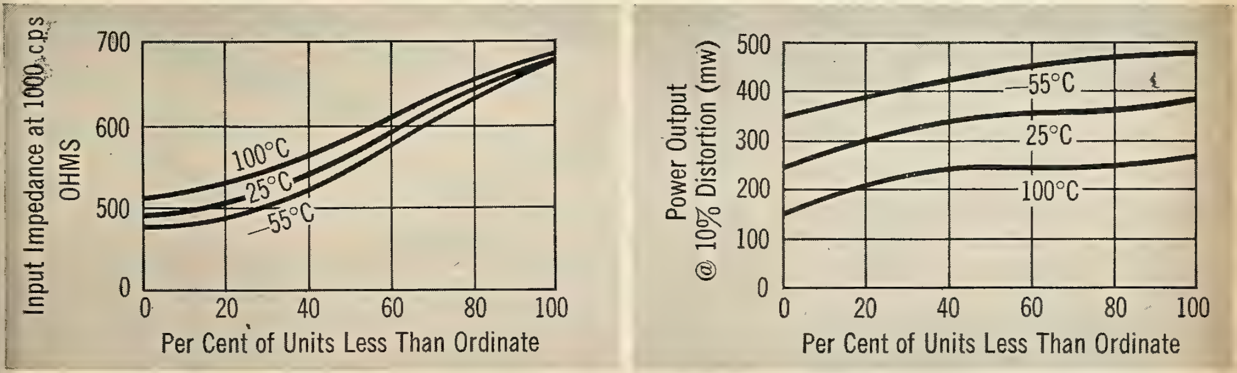

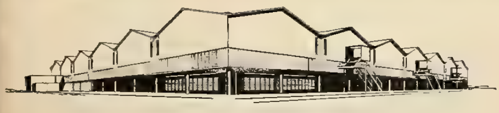

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contract awards

ARMY

$2,991,000—**Rocketdyne Div., North American Aviation, Inc.,** for classified design and development.

$2,010,910—**Corbetta Construction Co.,** Chicago, for construction of Missile Master facilities at Arlington Heights, Ill.

$1,050,000—**Sperry Phoenix Co.,** for universal automatic pilot.

$618,296—**E. I. Noxon Construction Co.,** Los Angeles, for *Atlas* assembly building at Vandenberg AFB.

$517,900—**The Firestone Tire & Rubber Co.,** for engineering services, modification of guided missiles and *Corporal* repair parts (three contracts).

$443,576—**Olin Mathieson Chemical Corp.,** for R&D on composite double base loading and firing missile, *Nike-Zeus*.

$395.842—**Eitel-McCullough, Inc.,** for electron tubes.

$349,947—**Nortronics Div., Northrop Aircraft, Inc.,** for a tape library.

$279,538—**Servo Corp. of America,** for Doppler radio detection finders.

$275,939—**Gilfillan Bros., Inc.,** for *Corporal* repair parts.

$230,698—**Rheem Manufacturing Co.,** Downey, Calif., for R&D.

$197,000—**Solar Aircraft Co.,** for terminal subsystems for space intercept study.

$175,000—**Machlett Laboratories, Inc.,** Springdale, Conn., for electron tubes.

$133,744—**Raytheon Manufacturing Co.,** for electron tubes.

$110,263—**Raytheon Manufacturing Co.,** for electronic assemblies for *Hawk* (an estimated 40% of this will be subcontracted).

$109,800—**Magnetic Research Corp.,** Hawthorne, Calif., for amplifiers.

$94,439—**ITT Laboratories,** Fort Wayne, Ind., for research on direct view integrating image converter tubes.

$91,628—**Western Electric Co., Inc.,** for *Nike* spare parts and components.

$89,386—**General Electric Co., Missiles and Space Vehicles Dept.,** for production of films in connection with Phase II of *Little John* program.

$85,318—**Mult-A-Frame Corp.,** Detroit, for fabrication of rocket storage racks.

$84,700—**Chicago Bridge & Iron Co.,** Atlanta, for construction of booster pump station reservoir at Redstone Arsenal.

$79,288—**Autonetics Div., North American Aviation, Inc.,** for services, spare parts, test equipment and accessories for the Juke Box computer.

$73,500—**North Carolina State College,** for study of motion of spin-stabilized rockets during burning, determination of launch parameters and development of instrumentation for determining experimental data, and to simplify analysis of this data.

$62,611—**Raytheon Manufacturing Co.,** for electronic components for *Hawk* missiles (two contracts).

$62,116—**Sanborn Co.,** Waltham, Mass., for oscillograph recording system.

$55,952—**Belock Instrument Corp.,** College Point, N.Y., for integrating gyro assemblies.

$50,285—**Arthur D. Little, Inc.,** Cambridge, Mass., for investigation of emissive properties of satellite surface before covering materials.

$50,000—**North American Aviation, Inc.,** for rocket engines.

$49,913—**Electro-Optical Systems, Inc.,** Pasadena, Calif., for R&D.

$40,000—**Douglas Aircraft Co., Inc.,** for rocket frame components.

AIR FORCE

$3,830,000—**American Machine & Foundry Co.,** for design and development of underground installation of guidance antenna for the *Titan* ICBM.

$898,333—**Air Products, Inc.,** Allentown, Pa., for liquid oxygen and liquid nitrogen.

$897,600—**Eitel-McCullough, Inc.,** for electron tubes.

$442,726—**Hoffman Laboratories, Inc.,** for liquid oxygen tanks.

$383,500—**Gilfillan Bros., Inc.,** for landing control set.

$289,880—**The Hallicrafters Co.,** for radar transmitters.

$232,310—**Cutler-Hammer, Inc., Airborne Instrument Lab.,** Mineola, N.Y., for design, development and fabrication of one molecular amplifier group.

$216,000—**Chance Vought Aircraft, Inc.,** for operation and maintenance of the Space Positioning Range near El Centro, Calif.

$163,070—**Sylvania Electric Products, Inc.,** for electron tubes (two contracts).

$150,000—**Westinghouse Electric Co.,** for high-power silicon transistor production refinement program.

$101,779—**Electronic Batteries, Inc.,** Brooklyn, N.Y., for storage batteries.

$100,288—**Electrical Specialties Co.,** Dayton, Ohio, for rectifiers.

$99,932—**Continental Electric Co.,** Geneva, Ill., for electron tubes.

$91,575—**Raytheon Manufacturing Co.,** for electron tubes.

$75,679—**Olin Mathieson Chemical Corp.,** for monomethyl hydrazine for testing and evaluation in support of Weapon System 138AA.

$69,646—**Vitro Laboratories Div., Vitro Corp. of America,** for continuation of research on high-intensity arc for ion propulsion.

$64,354—**RCA Defense Electronics Products Div.,** for design and development of airborne optical measurement system.

$58,176—**Westinghouse Electric Corp.,** for R&D on magneto-optical properties of ferri-magnetic rare earth garnets.

NAVY

$240,000—**New England Instrument Co.,** Woonsocket, R.I., for missile components for *Sparrow III* missiles (a subcontract from Raytheon).

$85,383—**Kearfott Co., Inc.,** Clifton, N.J., for synchros.

$74,778—**National Cash Register Co.,** Dayton, Ohio, for research in microencapsulation or reactive materials.

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by MIDVAC

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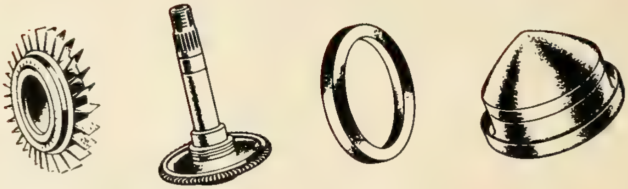
Offered in ingots, billets or forgings. Write for technical data on these new super alloy steels.



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people

DONOVAN

Allen F. Donovan, a vice president, has been named director of advanced systems planning for Space Technology Laboratories, Inc. The new advanced planning staff, according to STL, is a step toward "development of those systems which will be required in the future to replace today's ballistic missile and space systems." Donovan has held positions in the aircraft industry and with the Cornell Aeronautical Laboratory in R&D of manned aircraft, guided missiles and space vehicles. During four years with STL, he has been technical director for rocket vehicle aspects of the Air Force Ballistic Missile Programs.

Dr. Clark T. Randt has been appointed Scientist for Space Medical Research in the Office of Research Grants and Contracts of the National Aeronautics and Space Administration. He was Associate Professor of Neurology in the Department of Medicine, Western Reserve University, and Director of the Division of Neurology, University Hospitals, Cleveland. Dr. Randt will plan a long-range basic research program; it is expected that a large portion of the work will eventually be carried on by medical schools and other research organizations under Federal grants and contracts. In addition, Dr. Randt will assist NASA in human factors studies related to manned space flight.

Three new appointments have been made at Grand Central Rocket Co. **Albert T. Camp,** former head of the Propellant Division, Naval Ordnance Test Station, China Lake, is assistant vice president and director of research. Known for his direction of the *Sidewinder* missile and one of the top solid-propellant experts, he is credited with development of temperature-independent solid-propellant rockets and the explanatory formula for their combustion mechanisms. **John Gustavson,** Danish chemical engineer, was named senior engineer of the advance planning division for space propulsion. **Frederick F. Harris** was appointed director of Quality Control Div.

HARMONY

Joe C. Harmony has been named director of general engineering-receiving tubes for CBS-Hytron, the electronic manufacturing division of Columbia Broadcasting System, Inc. He replaces **E. K. Wimpy** who has been assigned to the new post of manager-marketing research. Harmony has served as manager of each of the firm's receiving tube plants and also as general manager of receiving tube operations.

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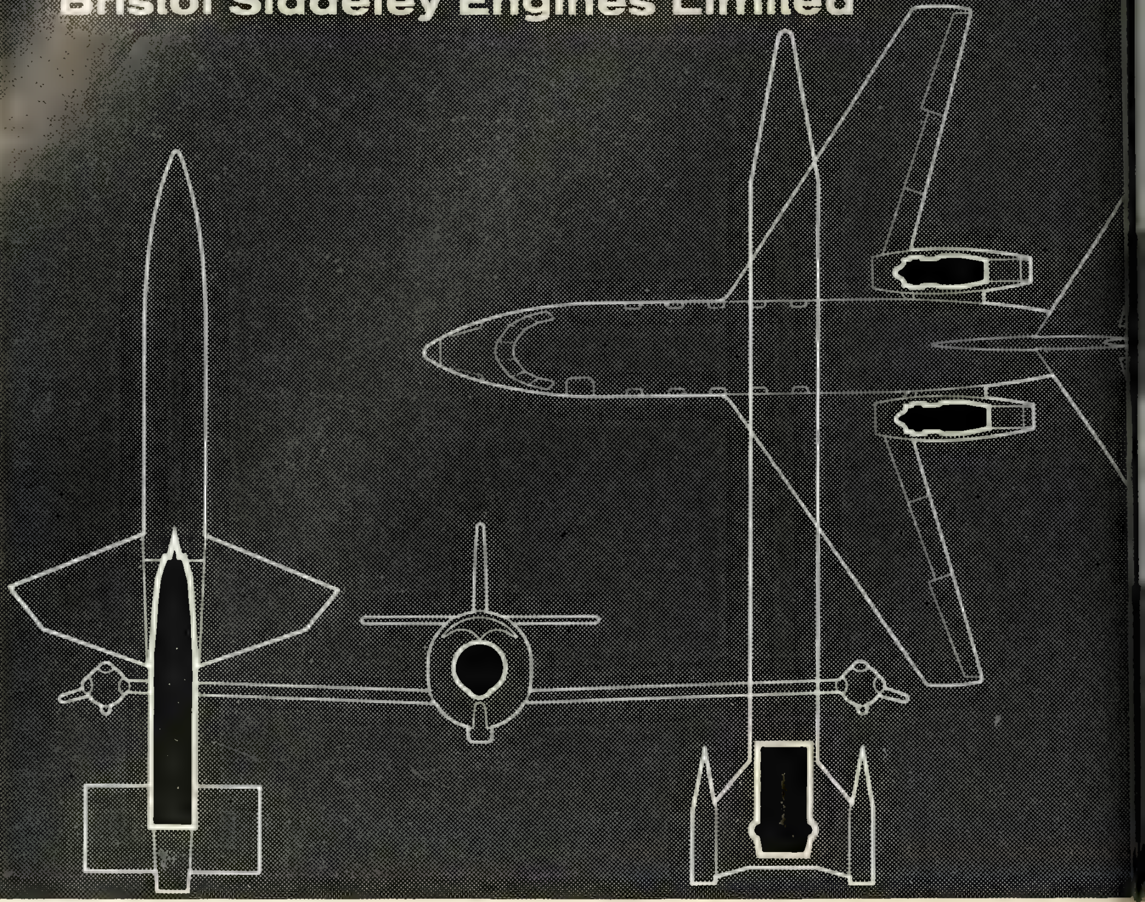
Bristol Siddeley Engines Limited



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Bristol Siddeley Engines Limited allies the minds, skills, resources of Bristol Aero-Engines and Armstrong Siddeley Motors to form a new giant of immense capability, immediately equipped for a dominant role in world aviation.

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ORPHEUS—leading lightweight medium-thrust turbojet . .

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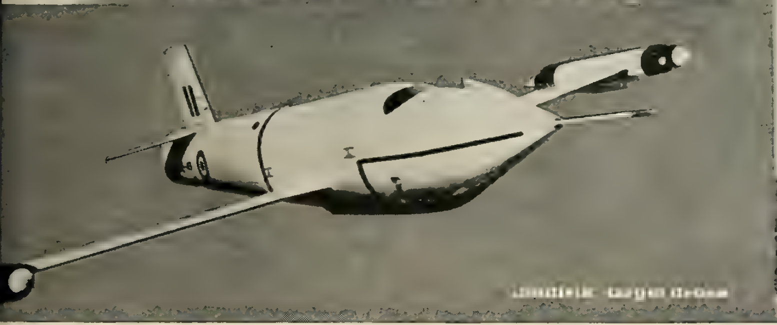


Jindivik target drone

Black Knight

eady specified in 8 countries for 14 different aircraft includ- the outstanding Lockheed Jetstar.

GLE MAMBA—jet-prop . . . stressed for naval operations such deck landing and catapulting . . . installed in the Short mew.

OR—a fully developed ramjet engine . . . powers the Bristol/ ranti Bloodhound guided missile system, chosen as Britain's jor air defence weapon, ordered by Sweden.

MMA ROCKET MOTORS—developed and produced as the power t of the successful Black Knight research rocket.

YMPUS—turbojet . . . remarkable for great power at high tude and very low fuel consumption . . . powerplant of the ro Vulcan bomber.

UBLE MAMBA—jet-prop . . . virtually twin-engined reliability long oversea reconnaissance duties . . . powers the Fairey nnet.

CENTAURUS AND HERCULES—two radial piston engines, with Bristol-pioneered sleeve-valves . . . renowned for their reliability and long overhaul life.

P181, P182—turboshafts . . . remarkably compact for power developed . . . P181 designed for helicopters, P182 for fixed-wing aircraft.

Bristol
Siddeley
ENGINES LIMITED

BRAIN·POWER translated into FLIGHT POWER

Circle No. 36 on Subscriber Service Card.

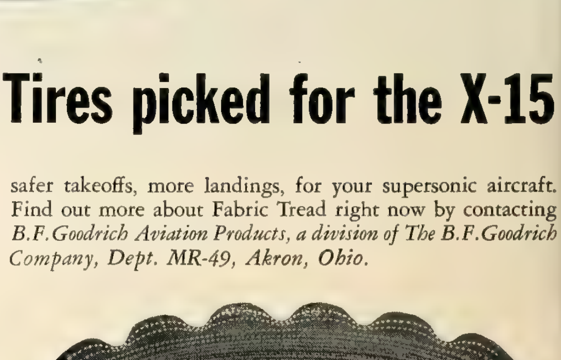
B. F. Goodrich Fabric Tread Tires picked for the X-15

Up, up — 100 miles up at fantastic speeds — the North American X-15 will carry man to the fringe of Earth's atmosphere. And when the X-15 lands it will land at a speed that will demand top tire performance.

That's why B.F.Goodrich Fabric Tread Tires have been selected for the nose wheels of the X-15. Already in service on our fastest jet fighters and missiles, these revolutionary B. F. Goodrich tires outperform all previous jet tires.

Nylon laminates built into tread stock reduce rubber distortion under load, equalize modulus between tread and carcass, check formation of "shock wave". Unique Fabric Tread designs eliminate stress points found in ordinary high-speed tires, also resist tread cutting and punctures.

Without a doubt, B.F.Goodrich Fabric Tread Tires mean safer takeoffs, more landings, for your supersonic aircraft. Find out more about Fabric Tread right now by contacting *B.F.Goodrich Aviation Products, a division of The B.F.Goodrich Company, Dept. MR-49, Akron, Ohio.*



Cross-section of Fabric Tread Tire showing nylon laminates

B.F.Goodrich ***aviation products***

Circle No. 37 on Subscriber Service Card.

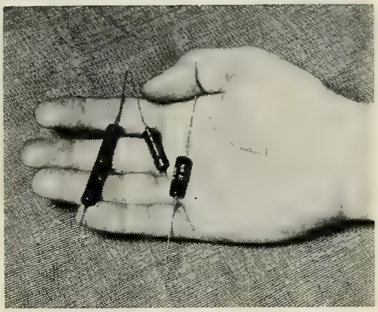
Novel Resistors 10 Times Smaller, Lighter

Market plans for new molecular-structured resistors, purported to be 10 times smaller and lighter than present resistance components, have been announced by **Daystrom-Weston Instruments, Daystrom, Inc.**

The micro-miniature resistors are the first commercial production of elements developed from the micro-module concept—the idea of combining extremely small elements of uniform shape and size into a single tiny module capable of performing complete circuit functions.

Basically, the micro-miniature resistors are a solid state material in the form of a ceramic wafer approximately 10 thousandths of an inch thick and .35-inch square. By processing suitable substrates, these micro-wafers are inscribed with a series of "isolation lines" which produce the resistor characteristics desired.

Single or double-sided resistor elements can be designed, and various combinations of circuitry can be employed with the basic micro-element.



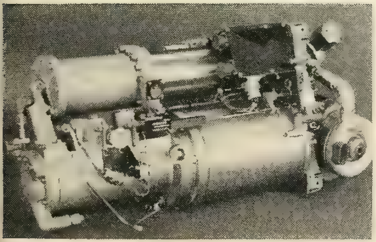
These wafer-like elements may then be combined into modules of standard size and shape comprising circuit sub-assemblies.

Each resistor element—weighing 50 milligrams—contains four resistors, averaging 10,000 elements (or 40,000 resistors) to the pound and a packing density of 600,000 parts per cubic foot.

The microscopic resistors are developed in wafer element forms designed for reliabilities of meantime to failure of 100,000 hours.

Circle No. 225 on Subscriber Service Card.

High Reliability Claimed For APU Power Unit



A new model auxiliary power unit, designed with an unprecedented maximum degree of reliability, simplicity and flexibility, to supply electric power for a missile's guidance and control systems has been developed by **The Garrett Corporation's AiResearch Manufacturing Division.**

The latest APU eliminates external plumbing, cuts the number of valves to less than half the number originally used on AiResearch APU's now being manufactured for the *Nike-Hercules.* It starts instantly and has better serviceability.

Designed to operate on ethylene oxide, the new AiResearch APU may also be used with hydrazine. With minor modifications a solid propellant can be utilized. Thus, the new unit provides maximum flexibility through the use of proven components available now, with the advantages of using other energy sources with adaptations.

The current model supplies five horsepower for a duration of 7½ minutes at specific load schedule. Its altitude range is from sea level to more than 100,000 feet.

Components in the AiResearch APU include a squib starting mechanism, variable delivery hydraulic pump, accumulator, reservoir, fuel tank, manifold valve assembly, alternator, speed control, and turbine drive unit.

The squib start initiates ethylene oxide decomposition by igniting a small replaceable solid propellant charge, which provides instantaneous starting capability without rearming the gas generator. The charge has been sized to assure acceleration of the turbine to rated speed within two seconds at ambient temperature as low as minus 65°F.

The variable delivery pump delivers required system flow at a pressure range of 2880 to 3200 psig.

A new design utilizes a single valve block to house all valves necessary for proper operation of the unit. This manifold valve assembly reduces the previously required number to seven.

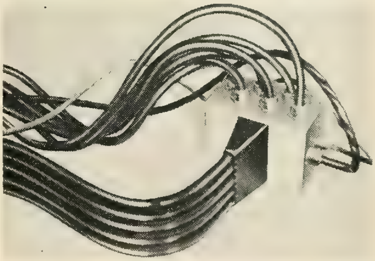
A new alternator for the APU has been designed which is a two-phase, permanent magnet, pad-mounted machine sized for existing requirement. One phase provides 30 volts ac for direct rectification to dc for operation of a fuel control valve. The second phase provides 120 volts ac for missile lift-off signal and the turbine frequency sensor.

The turbine is not subjected to adverse effect of step load changes resulting in better speed regulation. The turbine assembly has been redesigned to incorporate a pad-mounted, variable displacement pump and alternator, providing ease of replacement in the field. The turbine rotating assembly consists of a turbine wheel and shaft assembly.

The APU weighs 85 pounds less fuel and oil. It measures approximately 30 inches long, 12 wide and 15 high.

Circle No. 226 on Subscriber Service Card.

New Electronic Cable Utilizes Compact Assembly



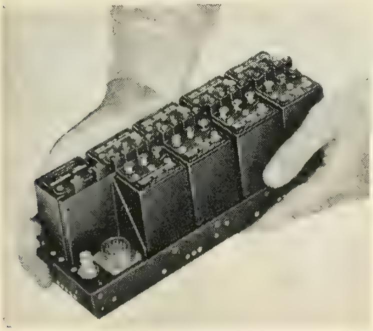
Custom electrical and electronic cable and cable assemblies designed to help solve missile cable problems are being manufactured by the **Aeronautical and Instrument Division, Robertshaw-Fulton Controls Co.**

Missiles use multi-conductor cable to link electronic components and systems, involving both airborne and ground support or test equipment, and as many as 30 to 40 electrical leads may be needed to connect complete electronic units. Conceivably, each lead might have a different material. Since it is no longer practical to string individually the many cables that may be required from blockhouse to launching pad, or from pad to missile, electrical conductors now are bound into compact cable assemblies, protected with suitable jacketing materials and provided with integral electrical connectors.

Cables are custom designed to meet customers, specific requirements and can be manufactured to nearly any length or size. They are manufactured on special planetary cabling machines designed by the firm. These unique machines are capable of completing the most precise and complex cables to meet the ever-increasing demand for specialized cable configurations.

Circle No. 228 on Subscriber Service Card.

T-Shaped Mini-Mount Aids Miniaturization



Smallest space installation of telemetry components within a missile is said to be made possible by the new Type 1405 mini-mount, manufactured by **Tele-Dynamics Inc.**

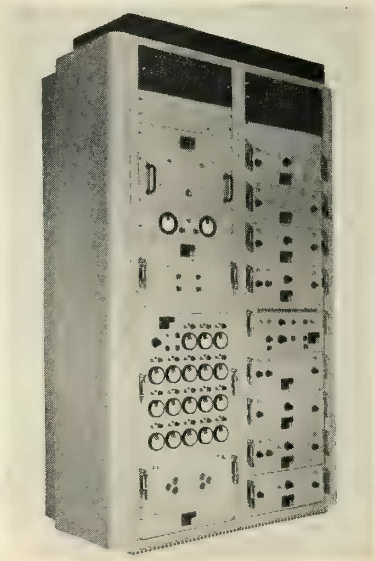
The mount is a pre-wired, welded "T"-shape which is designed to accept TDI type 1213A subcarrier oscillators and a TDI type 1106A wide-band amplifier. Sizes are available for four, eight, and 12 subcarrier channels.

The mount attaches directly to the vehicle structure and the miniature plug-in units contribute their own structural strength to the assembly when they become clamped to the T-member. All test points, trimmer controls, and receptacles are accessible.

Functionally the mount and its plug-in components act as the data input section of a telemetry transmitting system. Data voltages are applied to the subcarrier oscillators for conversion to FM information. The mixer amplifier provides a composite FM output which drives a telemetry transmitter. Inflight calibration is available through relays included in the mount base. When externally actuated, the relays connect fixed-level voltages, supplied externally, to the subcarrier oscillators to provide a standard frequency deviation.

Circle No. 229 on Subscriber Service Card.

Auto-Checkout For Telemetry Discriminators



A method for the improvement of reliability of FM/FM telemetered data is provided by the Model 5006 Automatic Discriminator Checkout System developed by **Dynatronics, Inc.,** Orlando, Fla.

This unit generates the 18 RDB standard FM/FM subcarrier frequencies simultaneously at 11 separate frequency deviations and also 18 simultaneous current outputs for comparison with outputs of discriminators under test. It provides automatic, semiautomatic, and manual operation.

In automatic mode up to 18 discriminators are fed with their respective channel frequencies and the output indicated by meters for comparison.

The channel frequencies are slaved to a master deviation selector which automatically drives through 11 deviations of plus or minus 1.5, 3, 4.5, 6, 7.5 and 0 percent.

Standard currents are likewise automatically compared with the discriminator at each point. If a meter reaches a preset limit the sequence is stopped and a light indicates the out-of-tolerance discriminator. Linearity of the discriminators to checked to better than 0.1%.

Circle No. 230 on Subscriber Service Card.

Tiny Mercury Battery, Capacitator Produced

A solid tantalum capacitor half the thickness of a dime, and a tiny mercury battery the size of an aspirin have been developed for the Army Micro-Module program according to an announcement by **P. R. Mallory & Co Inc.**

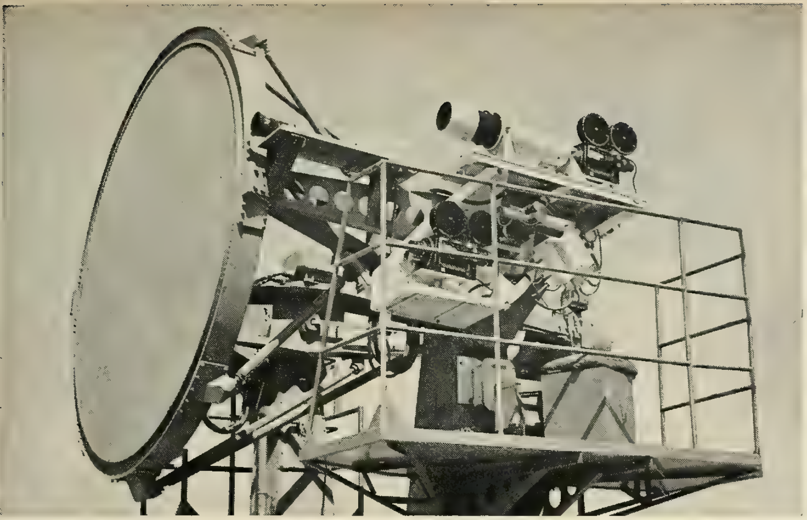
The Mallory micro-module tantalum capacitor was developed in two thicknesses, .028" in ratings up to 15 mfd x volts, and .35" in ratings up to 30 mfd x volts. Three different ratings and five terminal arrangements were developed in each thickness. The units have an effective operating temperature range of –65° to 85°C.

The Mallory RM 312 mercury battery was designed for modules requiring a self-contained source of power. The powerful little battery has a diameter of .305" and is only .135" thick.

The P. R. Mallory Co. is cooperating with RCA, the prime contractor for the Army Micro-Module program. The program was established to provide the Armed Forces with components and communications equipment physically reduced in size, but with no compromise in quality or reliability of performance.

Major emphasis of the program is on reducing the logistical problem through the development of electronic equipment that is less bulky and requires less technical know-how to operate than present equipment. Emphasis is also on reducing maintenance and "down time" through the use of "throw-away" component packages.

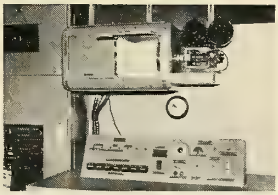
The micro-module as presently conceived, is the combining of micro-miniature transistors, capacitors, diodes and other components (called micro-



Mitchell Camera installation for radar tracking studies.

HOW MITCHELL CAMERAS SUPPLY VARIED DATA IN ROCKETS AND MISSILES DEVELOPMENT

- Exact Pin Registration During Film Exposure
- Event Time to 1 Millisecond



Data dial instrumentation by Mitchell camera.

Extensive testing instruments incorporating Mitchell 16mm, 35mm and 70mm cameras provide key data at the U.S. Naval Ordnance Test Station at China Lake, Calif., one of the primary weapon development centers of the Navy's Bureau of Ordnance.

Fifty Mitchell 35mm cameras are used on radars, tracking camera mounts and fixed tripods to record missile and rocket development. Camera motors allow synchronous as well as in-phase operation of several cameras covering a test...important in film assessing. Eight 16mm Mitchell cameras are used for pictorial coverage of tests.

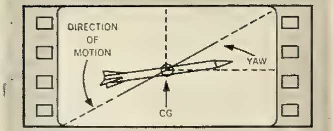
One metric photographic group shoots as much as 20,000 feet of 35mm film in one day. Other Mitchell cameras record underwater, engineering and aviation tests at this ordnance center.

For information on Mitchell cameras, write describing your requirements.

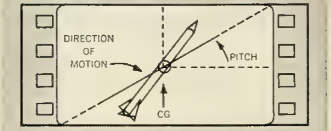
Mitchell Camera
CORPORATION
666 WEST HARVARD STREET
GLENDALE 4, CALIFORNIA
Cable Address: "MITCAMCO"

85% Of Professional Motion Pictures Shown Throughout The World Are Filmed With Mitchell Cameras

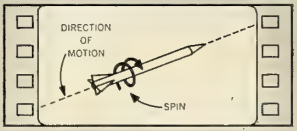
The Mitchell camera, by virtue of its exact pin registration during film exposure, allows these data to be determined to a reasonably high degree of accuracy through the use of film assessing equipment built to take advantage of this feature:



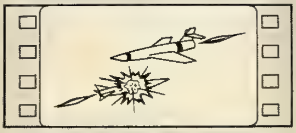
Yaw—Side-to-side motion of missile.



Pitch—Up-and-down motion of missile.

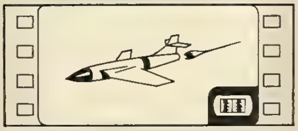


Roll—Turning motion of missile.

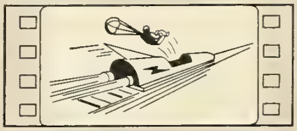


Miss Distance—Gap between missile and target at point of interception.

Flight Time—A series of lines on film; timed to accuracy of 1 millisecond.



Position Data—Target location with azimuth and elevation readings.



Pictorial Record—Record of all visible actions during test.

Separation Data—High-speed separation actions for detailed study.

Circle No. 38 on Subscriber Service Card.

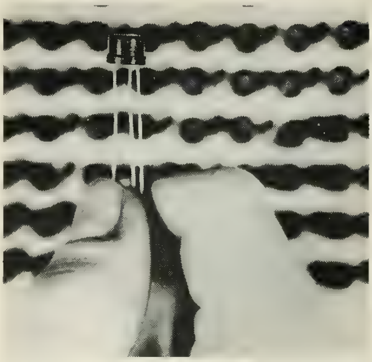
elements) suitably combined to form a sealed or encapsulated solid body. These module units are so designed or packaged to make reasonable the discard of the entire unit when any one component goes bad.

Circle No. 231 on Subscriber Service Card.

Diode Switch Has Fast Triggering Time

A 200-milliwatt Dynistor diode switch is now available in commercial quantities from **Westinghouse Electric Corp.** The device is a multi-junction, two-terminal germanium switch that can transfer from a blocking to a conductive condition in fractions of a microsecond. This switching time is considerably shorter than that of switching transistors of comparable power handling capacities.

In the 200-milliwatt rating, the Dynistor diode can be used for applications in computers and core-driver circuitry. It can also be used as a protection against transient overvoltages, as an oscillator, a sawtooth wave generator, a fast acting relay, and a phase controlled rectifier, among other applications. The device is available in four breakover-voltage categories ranging from 50 to 200 volts.



In operation, the Dynistor diode is triggered by a short duration trigger pulse, which can be of less than one-microsecond duration, and of sufficient magnitude to insure raising the voltage on the device above its breakover voltage.

To turn the device off, the voltage must momentarily be reduced to zero, or the current through the device must be reduced below minimum sustaining current. Thus, it is essentially an on-off switch similar in operation to a gas discharge tube or neon bulb. The major difference is that the voltage drop in the conducting condition of the diode is less than a volt. The faster switching times, ranges of breakover voltages, and small size are other major differences. The unit is encapsulated in a JETEC Type 30 case.

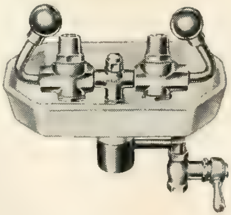
Circle No. 232 on Subscriber Service Card.

Ultrasonic Delay Lines Have Wide Period Range

Development of ultrasonic delay lines with very short and long delay times has been announced by **Corning Glass Works.** They will store a signal with minimum attenuation for periods ranging from less than 50 to more than 15,000 microseconds.

Ultrasonic delay lines are produced by Corning for military radar systems. The new, very short and very long delay lines greatly extend the range of possible delay times.

Ultra-short delay lines were de-



Protect Eyes

with **HAWS EMERGENCY EYE-WASH FOUNTAINS**

Model 8930:
Basic eye-wash model; enameled iron bowl, chrome plated brass heads. HAWS also offers eye and face wash fountains and drench showers.

Chemicals, foreign particles, caustics — all mean DANGER to eyes! Instant relief is vital! HAWS Eye-Wash Fountains flood the eyes with controlled water streams — soothing, relieving until medical aid arrives. Fool-proof operation activates fountain instantly, possibly avoiding permanent injury. HAWS Emergency Facilities are also widely used for routine cleansing of eyes as a precautionary measure. Write today for illustrated literature on HAWS complete line of emergency facilities.

HAWS DRINKING FAUCET CO.
(Since 1909)
1443 FOURTH STREET
BERKELEY 10, CALIFORNIA

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℞ FOR INTERNAL INSPECTION

● **0.10" AND UP** . . . That's the point of entry requirement . . . to provide your inspectors the chance to use the outstanding National Fontar Borescope and thus give them the brightest, distortion-free, close-up view of the defect in "inaccessible" interior surfaces of the cast, drawn, welded or molded product . . . from inches deep to many feet.

Find out how its use can be a time and cost saver while it up-grades your Quality Control. Just send for our "Borescope Catalog."

ENGELHARD INDUSTRIES, INC.
NATIONAL ELECTRIC INSTRUMENT DIVISION
92—21 Corona Avenue • Elmhurst 73, New York

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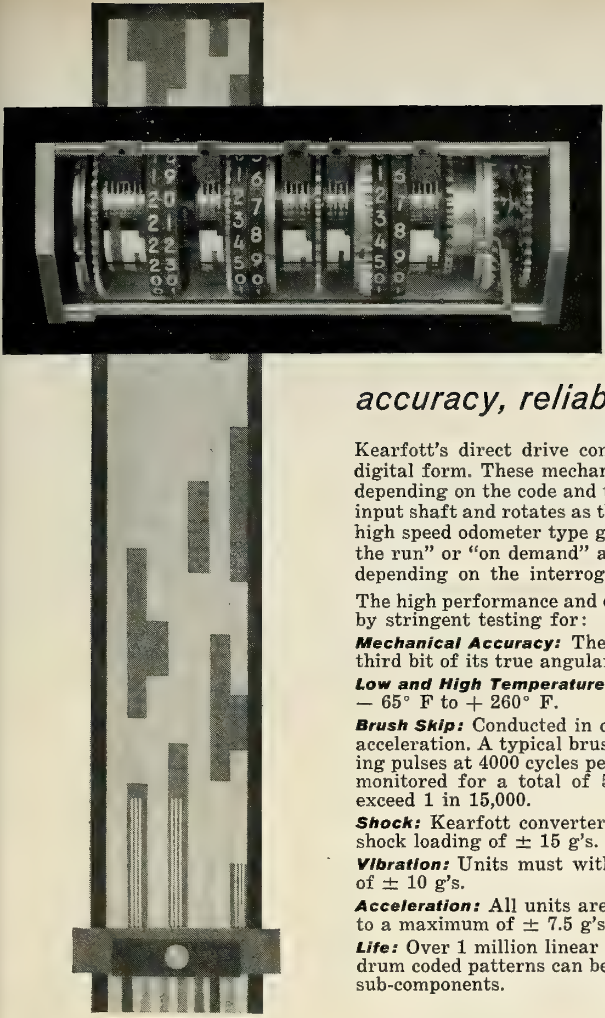

. . . Kearfott analog-to-digital converters

accuracy, reliability, varied capacities and codings

Kearfott's direct drive converters translate shaft rotation into electrical and visual digital form. These mechanically positioned units consist of coded drums, the number depending on the code and total count. The first, or units drum, connects directly to the input shaft and rotates as the shaft turns. On models where more than one drum is used, high speed odometer type gearing provides interconnection. All models can be read "on the run" or "on demand" and all tracks may produce simultaneous or serial readings, depending on the interrogating pulse.

The high performance and quality of Kearfott's analog-to-digital converters are assured by stringent testing for:

Mechanical Accuracy: The location of any code transition point must fall within one-third bit of its true angular position.

Low and High Temperature: All units operate efficiently at temperatures ranging from − 65° F to + 260° F.

Brush Skip: Conducted in conjunction with tests for temperature, vibration, shock and acceleration. A typical brush skip test employs 200 μsec., 23V DC amplitude interrogating pulses at 4000 cycles per second. With the shaft rotating, each output drum track is monitored for a total of 500,000 pulses, in which "lost" counts or "skips" will not exceed 1 in 15,000.

Shock: Kearfott converters are subjected to 18 shocks in three different planes with shock loading of ± 15 g's.

Vibration: Units must withstand vibrations between 5 and 500 cps with applied load of ± 10 g's.

Acceleration: All units are subjected to radial accelerations of varying magnitudes up to a maximum of ± 7.5 g's.

Life: Over 1 million linear feet (1000 hours at 82 RPM) of continuous brush travel on drum coded patterns can be achieved without excessive wear to drums, brushes or other sub-components.

Write for new ADAC brochure.

ANALOG-TO-DIGITAL CONVERTER CHARACTERISTICS

Kearfott Unit No.	423830-1	423607-1	Y1241-11A	P1240-11A	Y1240-11A	U1240-11	P1241-11A
Code (1)	B.D.	B.D.	B.D.	B.D.	B.D.	B.D.	C.B. (Gray)
No. of Drums	1	1	2	3	3	4	5
Range	0 to 84 in 348.5° of arc. 11.5° dead spot coded O	−19 to 0 to + 19	0 to 359	(+) 0 to (+) 999 (−) 999 to (−) 0	0 to 359.9	0 to 359.9	0-32,768 (2^{15})
Bits per Revolution	85	39	40	20	40	40	16
Revolutions for Total Range	1	1	9	100	90	90	2,048
Volts D.C.	23	12	23	23	23	23	10.5
Current (ma.)	20	20	20	20	20	20	20
Inertia (gm. cm.^{2}) (2)	158	48	104	28	158	100	20
Unit Diameter (in.)	$2\frac{1}{8}$	$1\frac{3}{4}$	$1\frac{15}{16}$	$1\frac{7}{16}$	$1\frac{15}{16}$	1.875	$1\frac{7}{16}$
Unit Length (in.)	31/32	$1\frac{1}{16}$	1-43/64	$1\frac{15}{16}$	$2\frac{3}{16}$	2.8125	3
Life (3)	10^6 revolutions or 10^3 hours						
Static Torque (in.-oz.) (4)	0.5	0.1	1.0	.5	1.0	1.0	2 (break) 1 (running)
Weight (oz.)	5	3.5	5.75	4	7.75	6.5	5
Maximum Speed (RPM)	1100	250	300	400	300	700	600
Dielectric (Volts DC)	500	500	500	500	500	500	500

(1) B.D. (Binary Decimal), C.B. (Cyclic Binary).

(2) Inertia measured at maximum trip.

(3) Under recommended conditions.

(4) At room temperature.

Engineers: *Kearfott offers challenging opportunities in advanced component and system development.*

Kearfott

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PRECISION
COMPANY

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West Coast Office: 253 N. Vinedo Avenue, Pasadena, Calif.

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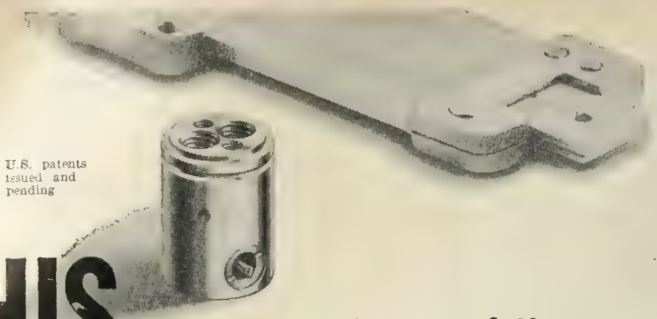

THIS is the actual size of the world's simplest acceleration switch.

It represents a totally new concept in acceleration sensing devices. Weight: about one ounce. Only one moving part: a precision ground ball held by an alnico magnet. The ball is released to close or open an electric circuit when the force of acceleration exceeds the magnet's pull.

It's as simple as that. Yet this versatile I-S design makes possible switches that respond axially, radially, or omnidirectionally, from 0.01 g to 500 gs. With adjustable g settings, if you desire. Automatic reset is optional. Closure time is variable. Accurate within 0.1%. Meets all applicable Mil specs.

But more than an ingenious design, the I-S switch represents an important attitude . . . an attitude that produces only equipment of sound and simple design and reliable performance, of uses limited only by your needs.

Try us; write today for descriptive brochure MR-459.

INERTIA SWITCH, INC. 311 W. 43rd St., New York 36 • JUdson 6-5880

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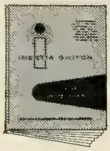
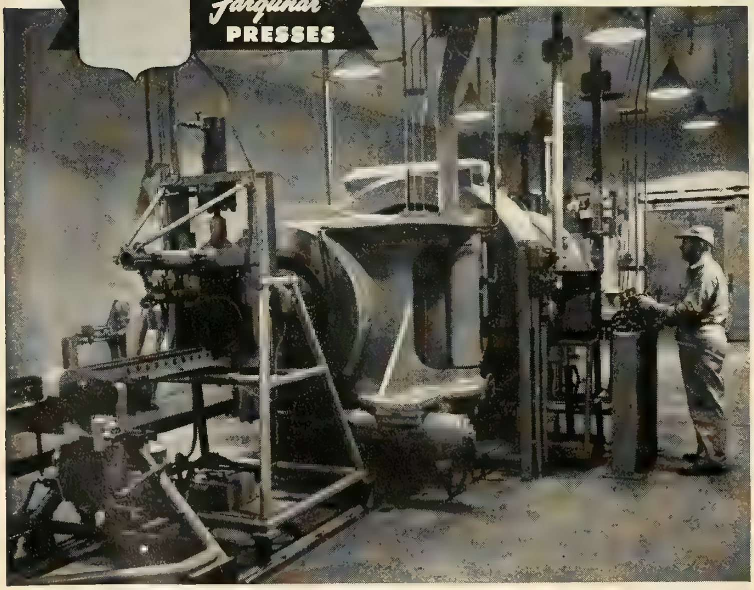


OLIVER Farquhar PRESSES



At Astrodyne's plant in McGregor, Texas, this Oliver-Farquhar 2140-Ton Hydraulic Extruding Press does its work in the silence of its own cell, compacting today's powerful solid rocket propellents. All movements of this unique press are programmed and recorded in a central control bunker placed at a safe distance from the unmanned press cell.

Write, wire or phone for complete information or ask for our recommendations and proposals. The Oliver Corporation, A. B. Farquhar Division, Press and Special Machinery Departments, York 6, Penna.

Circle No. 43 on Subscriber Service Card.

veloped through glass composition research at Corning. The new glasses have nearly a zero temperature coefficient of time delay, and can provide delay times up to several hundred microseconds without the need for bulky and heavy heating equipment.

The glasses are manufactured by the same techniques used in production of optical glass and therefore can be formed into standard glass shapes.

The very long delay lines were developed through improvements in fused silica production methods, which make it impossible to form plates of pure fused silica up to 48 inches in diameter. The extremely low acoustic attenuation of fused silica makes possible delay times of 15,000 microseconds in a single plane delay line.

The company formerly achieved maximum delays of 5250 microseconds by using folded, or multiple, delay lines.

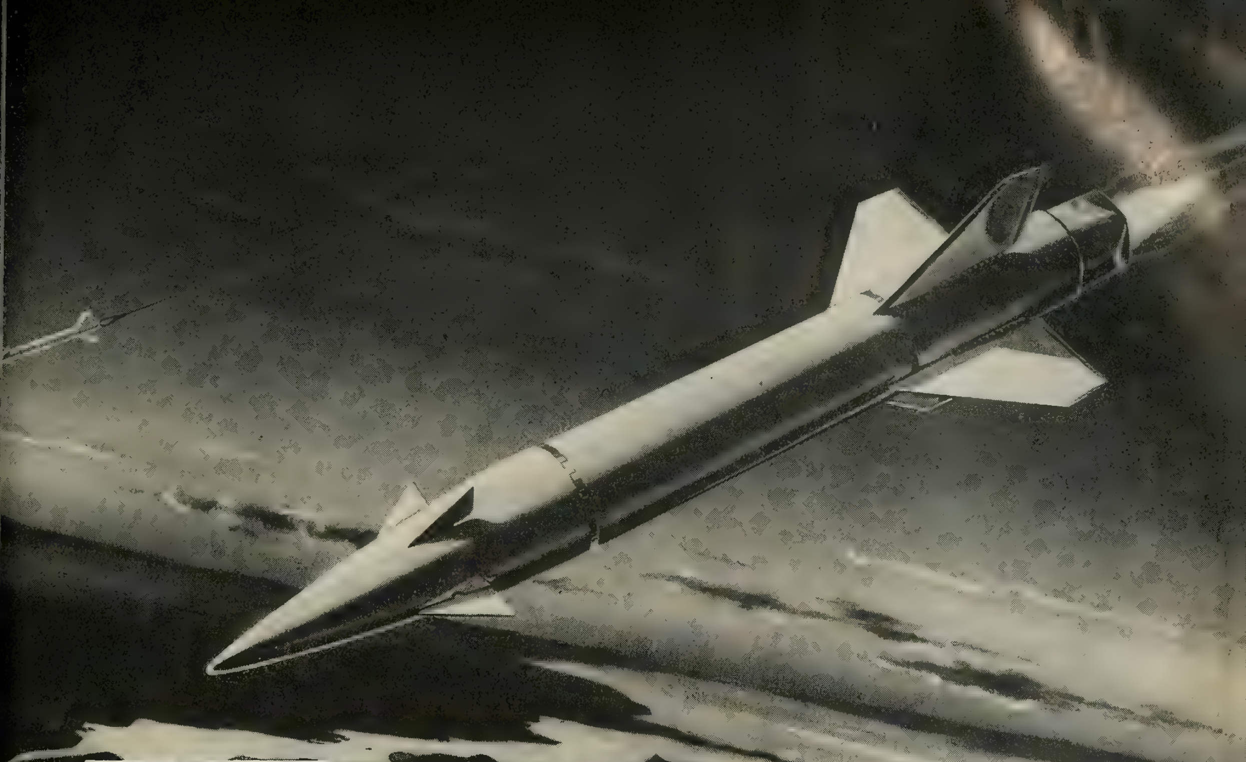
Fused silica is produced by a unique evaporation process developed by Corning research scientists. The material is said to be one of the purest man-made substances.

Circle No. 233 on Surbscriber Service Card.

Ball Bushings Weigh Only 0.15 of an Ounce

Thomson Industries, Inc., has commenced producing miniaturized linear ball bushings specifically designed for military systems requirements requiring miniaturization.

Designated INST-396, those ball bushings are for use on shaft diameters of 0.1246″ and 0.1871″. Overall dimensions are: O.D.—0.3125″, Length—0.5″ and 0.375″ and 0.562″ respectively. They weigh only 0.15 and 0.30 ounces. Despite small size, each bearing contains three complete ball circuits with each circuit containing 16



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Fabrication of precision ball circuits in this miniature size was made possible by the development of special milling techniques, using a 16 to 1 pantograph ratio.

Although small in size, these bushings possess all of the supersensitive characteristics of the larger and heavier instrument quality bushings. In addition, they are said to be extremely rugged in construction and capable of withstanding high vibrational and shock loads. The precision manufacturing techniques, combined with the anti-friction rolling design, assure minimum static and rolling friction together with a high degree of reliability and repeatability.

The miniature bushings consist of three basic parts: an outer sleeve and balls made from stainless steel and a ball retainer made from brass. An alternate material is 52100 chrome bearing steel. All parts are precision machined and then individually inspected for both surface finish and dimensions. Each bearing is also individually tested for sensitivity.

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Rocket Shut-off Valve Produced for New ICBM

A six-inch rocket propellant shut-off valve for remote control has been developed for a major ICBM by the **Clary Dynamics Division of Clary Corp.**

The gate valve can be controlled electrically or manually and is designed for pneumatic or hydraulic actuation.

It is designed to operate at –35 to +160°F with a response time of .5 to 1.5 seconds. With minor modifications, the shut-off valve will operate at temperatures of –320 to +250°F.

Leakage rate with upstream fuel pressurization of 12 PSIG is .5 CC's per minute; leakage with downstream air pressurization of 50 PSIG is less than 10 CC's per minute. Maximum operating pressure is 60 PSIG.

The shut-off valve will pass a flow of standard liquid fuels at the rate of 2000 gallons per minute with a pressure drop of .31 PSIG. It weighs 16½ pounds.

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(Continued from page 33)

other gain stage following the threshold circuit.

Azimuth-position voltage (0.2 vdc/-degree) is derived from a precision potentiometer (see position pickoff, Fig. 2). Elevation sweep, defined by the position of the commutator, is derived from a sawtooth generator circuit. The sawtooth synchronizing signal is from a variable reluctance pickoff. Two pulses per commutator rotation correspond to the two commutation cycles per rotation.

• **Performance**—The calculated sensitivity of CODES is 2 x 10^{-11} watts/-cm^2 for a probability of detection of 80% per frame and a false alarm rate of 10/hr. When testing CODES, the signal from one cell was processed. The system noise equivalent input was observed as 1.6 x 10^{-11} watts/cm^2 in the 1.8 to 2.7 micron band. Then all of the system was operated at a low false alarm rate. For a 50% single-scan probability of detection, a signal of 2 x 10^{-10} watts/cm^2 was required. This corresponds to an S/N for one cell of approximately 12. It can be shown, however, that for low false alarm rates 50% detection probability should be an S/N of 4. Thus the detection capability of the demonstrator compared with one cell is reduced by a factor of 3.

Operational models of CODES, when optimized, will be more compact and lighter. According to Harvey Dubner, manager of Avion's Advanced Development Laboratory, this will be achieved in part by eliminating the rocking plane mirror as the scanning collector. Instead, scanning in future models will be accomplished by rotating or rocking the whole unit. The adaptation will of course vary with application and the vehicle.

• **Corrections**—Measured sensitivity in the demonstrator is correctable by optimizing the optical transmission. Also, the original unit was operated under a limiting condition from a source other than cell noise. A 1-db noise rise was measured between cell bias "on" and "off." Cells are available with improved contour and of improved materials for higher level operation that will increase the usable signal, after commutation, by a factor of 1.7.

In pilot production now, an Avion spokesman said the company will be ready for regular production of operational models in 8 to 12 months. At that time, cost for small quantities will be "under $5,000."

ENGINEERS

General Electric's Advanced Electronics Center *Announces* the construction of its new R&D Laboratory at Cornell University's Industrial Research Park

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NEW PRODUCT BRIEFS

ACHINE UNIT. Simplex machine unit rings, constructed to meet low-cost uirements of many applications, e been introduced by Hoover Ball Bearing Company. Designed for t loads at normal speeds, the mane unit includes a single row bear- of deepgroove design with extended er ring, equipped with two set screws locking the bearing on its shaft. oarable seals may be used either gly or on both sides of bearing. A e lock ring holds the entire unit seely in its straight bore housing. rings are available in shaft sizes m ½" through 1-3/16".
le No. 245 on Subscriber Service Card.

NYL CABLE FILTER. Wicoa "Non" cable filler, developed to replace , cotton or other similar filler maals for environmental grade military ctronic cables, has been announced the Wire Co. of America. The filler a flexible rod of fungus-resistant, -hygroscopic vinyl, extruded over a tral core of glass fiber, which prets stretching. It is named "No-Con" ause it is a non-conductor rod and not, in error, be soldered to an ctrical connector. Certified as an ironmental grade material to conn to specifications MIL-C-915-A and L-E-5272A, its operating temperature ge is minus 80°F to plus 200°F. It vailable in a full range of diameters, n .050" to .250" on spools up to 000' continuous lengths.
le No. 246 on Subscriber Service Card.

SELESS POWER SUPPLY. Developnt of a 6-36 volt dc at 15 amperes nsistorized transient-free power sup- has been announced by Perkin Eneering Corp. Model No. MTR636- is designed for testing transistorized cuits where transistor failure occurs the conventional statically-regud power supplies due to line and d transients. This unit has a regula of ±25 millivolts; a ripple of 5 ivolts RMS maximum and dynamic edance of 50 milliohms maximum n 0-20KC. No output fuses are rered due to an automatic current ting circuit which provides overload l short circuit protection automatic. Conservative design within the unit mits operation at 15 amperes with nterrupted service, even in the case a transistor failure. It features magic amplifier regulation for regulation ripple specifications.
le No. 247 on Subscriber Service Card.

UHF CONNECTOR. Edlen Inc. has announced the production of a new UHF connector, designated the Crimpee CR-8-UF. The connector is a 50 OHM matched fitting which requires no soldering, eliminating the problem of melted dielectric. The outer shell makes positive 360° contact with the cable braid. The connector is compatible with all existing connectors, and will fit the SO-239 socket. Mechanically strong, the cable braid will break before the connector pulls apart. The insulator is made of teflon, and the other parts are silver plated brass.
Circle No. 248 on Subscriber Service Card.

DIGITAL VOLTMETER. An all-electronic digital voltmeter, capable of making 50 measurements per second, is now being marketed by Electro Instruments Inc. The four-digit model 8409 features totally transistorized logic circuits; ± digit accuracy; automatic polarity; automatic, manual and remote ranging; 1000 meg ohm input impedance; BCD and decimal output; direct printer operation; provision for external reference voltage; and modular construction throughout.
Circle No. 249 on Subscriber Service Card.

CURVE TRACER. A transistor curve tracer for engineering, training, production and servicing applications has been developed by the Inter-Mountain Instruments Branch of Curtiss-Wright Corp.'s Electronics Div. Known as model TCT-2, the instrument can display either one curve or a five curve family. The V_c and I_c waves are directly calibrated. It displays collector voltage-collector current (output) curves for common emitter or common base connection. The tracer is designed for use with any standard DC oscilloscope with single presentation possible with any standard AC oscilloscope. Another feature of the transistor curve tracer is that emitter-base voltage for selected input currents may be measured by using an external DC meter to characterize points on the input curve.
Circle No. 250 on Subscriber Service Card.

DELAY LINE. Control Electronics Co. has developed a compact lag-type delay line for use with signals in the sonic frequency range. Known as the F344, this lag type delay line has an impedance of 1100 ohms, a band width of 15 kcs and a total delay of 76 microseconds.
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MISSILE LITERATURE

PRINTED CIRCUITS. A booklet on "Reliability and Cost in Printed Circuits" has recently been issued by the Arthur Ansley Manufacturing Co. It discusses the relationship between various factors affecting both cost and reliability and points out that the proper printed circuit design may simultaneously cut overall cost and increase reliability. The greater care needed to manufacture high reliability printed circuits does of course, increase initial cost, but in military and industrial electronic equipment this increase is well justified.

Circle No. 200 on Subscriber Service Card.

FORGING. The Cameron Iron Works has released a brochure describing its plant and the scope of its forging development. The brochure depicts Cameron facilities for forging high densite steels into jet engine components; stainless steels into nuclear reactors, jet engines and steam power components, and high-quality alloy steels into short-lived missile components.

Circle No. 201 on Subscriber Service Card.

ACTUATORS. A 15-page booklet describing linear and rotary hydraulic servo actuators, is offered by the Dalmo Victor Co. These units are designed for use in applications requiring wide dynamics speed range and high-frequency response performance. Booklet includes design and flow requirements needed to meet specified servo loop performance figures.

Circle No. 202 on Subscriber Service Card.

MAGNETIC SERVOS. An eight-page color brochure entitled, "High Power Transistor Magnetic Servo Amplifiers," has been published by Magnetic Amplifiers, Inc. Illustrated with photographs, diagrams and charts, the booklet, designated Bulletin S-961, describes the manufacturer's "Advanced Design 'B' Line" of servo amplifiers built for industrial and military use. Applications cover power control for such varied equipment as automated milling machines, lathes, jig boring machines, camera and light positioning systems, computers, optical tracking systems, inertial platforms and radar antenna positioning systems. Technical data deals with 1 to 4 stage systems, utilizing AC or DC inputs with transistor-magnetic or all magnetic configurations for 60 and 400 cycle per second systems. Detailed engineering and performance specifications are given for each system.

Circle No. 203 on Subscriber Service Card.

STATISTICS. A new and expanded 1959 edition of EIA's statistical series on the electronics industry is now available. New areas added include statistics and products in the consumer area, a complete electronics industrial products dossier, and military electronics data covering aircraft, missilery, and government expenditures. Copies of the 5th annual "Fact Book" for 1959 prepared by the EIA Marketing Data Department are available to non-EIA members for 75 cents.

Circle No. 204 on Subscriber Service Card.

TELEMETRY. A reference bulletin to engineers in planning telemetry rece ing systems has been issued by Te Dynamics Inc. The miniature FM Te metry Receiving Systems Bulletin ill trates typical systems and describes dividual TDI building-block componen receivers, subcarrier discriminators, m ter controls, record-monitor-mixers, pov supplies, and pre-wired mounts. Descr tions also cover the widely used TDI commutation Set and Tape Error Co pensation System. The bulletin goes i detailed examples of systems for rece ing FM/FM, PAM/FM/FM, PDM/FM FM signals.

Circle No. 205 on Subscriber Service Ca

PULSE TRANSFORMERS. A new te nical bulletin describing the P Ser miniature encapsulated pulse tra formers, designed especially for print circuit and automatic assembly appli tions, has just been published by Te nitrol Engineering Co. The P Series wound on high-permeability ferrom netic cores, resulting in a transforn design with a high pulse-width to ri time ratio. The units are available in number of case styles with a range pulse widths from 0.05 to 10 mic seconds for either vacuum tube or tr sistor applications. The small height the transformer case and special pin rangements make them particularly su able for printed circuit boards, while guide key on the side of the ca which fits cylindrical feed devices, ma the transformers ideal for producti runs using automatic assembly machin

Circle No. 206 on Subscriber Service Ca

ANTENNAS. A revised and expand second edition of the "I-T-E Anten Handbook" has just been published. T I-T-E Circuit Breaker Co. has writt strictly for the antenna systems en neer. This small book provides curves estimating antenna performance and t physical characteristics required achieve a particular antenna perfor ance. It should be particularly valuab to those in the fields of radar a microwave communications.

Circle No. 207 on Subscriber Service Car

TITANIUM. A brochure on titanium h been published by Harvey Aluminu The 36-page booklet is intended as reference for engineers, metallurgis and designers. A section on how tanium is made discusses in detail co version of the basis ore into sponge a melting of sponge into ingot form. T publication also describes advantages titanium covering strength and weigl high-temperature performance, fatig strength, corrosion resistance, erosi resistance, and thermal properties. rating chart outlines corrosion properti of the metal and specifications a characteristics of the various titaniu alloys.

Circle No. 208 on Subscriber Service Ca

SILICON. A catalogue outlining t production techniques and various typ of silicon diodes and transistors h been released by the Semiconduct Division of the Sperry Rand Corp.

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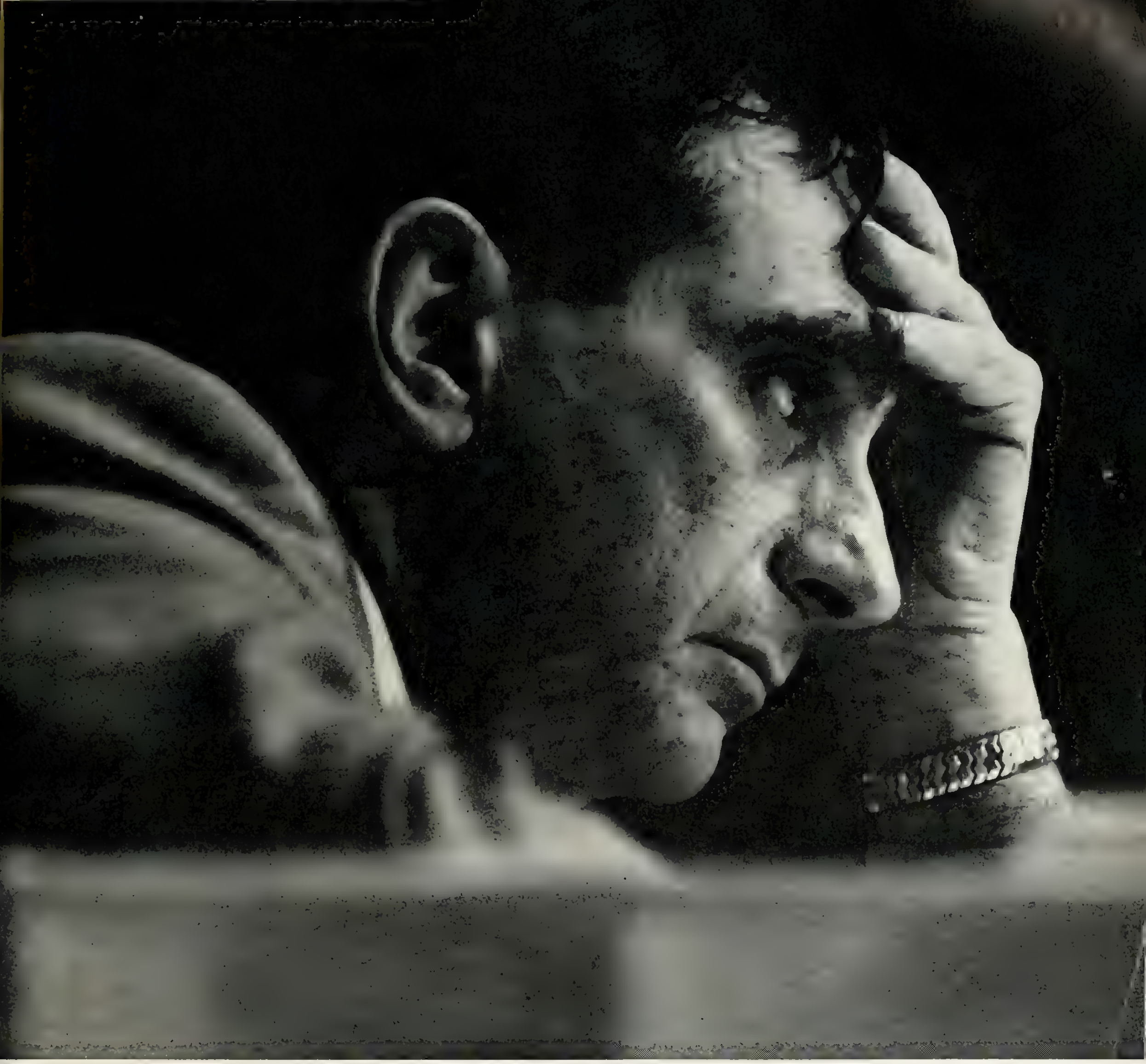
Proposes test of Einstein theory



missiles and rockets

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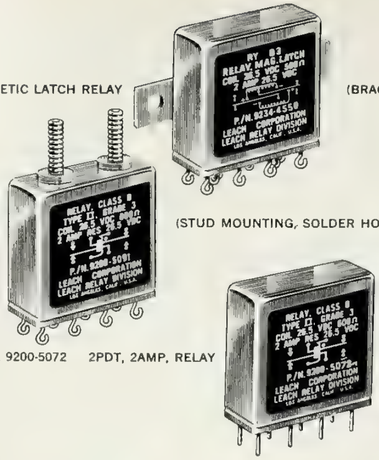
AN AMERICAN AVIATION PUBLICATION



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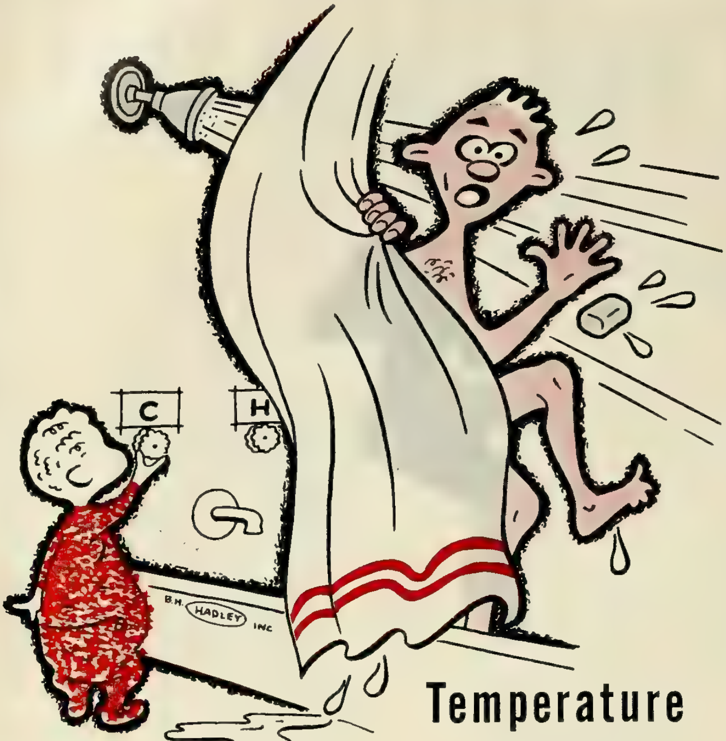

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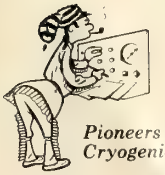

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missiles and rockets

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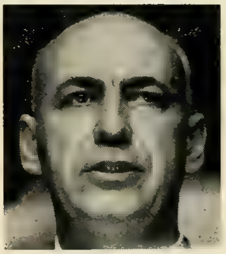
ARPA's John E. Clark stressed close tie-in of military and civil space projects. . .

AFA Pres. Peter J. Schenck presided over Missile Management Conference. . .



NASA's Robert Gilruth outlined *Mercury* project and civilian space plans. . .

SPACE Age conference was chaired by ARS President John P. Stapp (See pages 34-41)

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Let's Consider the Optik

At the beginning of a press conference following a recent space launching by NASA, one front-row correspondent opened the questioning thusly:

"Would it be asking too much to stick to one term of measurement in this exercise? Last week we had feet per second. The week before it was miles per minute and before that we had knots. What are we having this time, something different?" (They were.)

The reporter's plea is only a faint echo of the space scientist, who can work with and convert all the terms mentioned above but finds that none of them is really appropriate in the space exploration field.

In this week's M/R a guest author makes an honest appeal to the scientific community for standardization of velocity terms and units. He suggests that feet-per-second, miles-per-hour and the metric system fail miserably in the space environment. He observes that the missile and space industry is now at a critical time when serious consideration must be given to changing units of measurement—particularly as related to high velocity—and that a change later will cost us far more in the long run than the cost of changing now.

He paraphrases a comment by Dr. Hubertus Strughold, a contributing editor of this magazine, in which Dr. Strughold commented:

"We should bestir ourselves now, while on the threshold of the space age, to systematize our units of measure to avoid further loss of manpower and efficiency from this source."

The author of this week's article, Maj. William C. Mannix, formerly with ARDC and now with Headquarters, USAF, has a suggested solution for the problem which he offers for use or for comment. He suggests that the velocity of light, which is constant and measurable, be used; he has divided this velocity of light into units and for the unit he has provided a name—Optik. He admits this may not be the best word and would be happy to see a better one. The spelling is for non-English-speaking users of the word. He thinks "einstein" or "roemer" which have been suggested before might also be considered.

Major Mannix convincingly states that as new scientific frontiers are established we find that some of our familiar terms are no longer clear and must be redefined. For example, "hypervelocity" means a great many things to a great many people, but with no general agreement.

New barriers are being broken and new distances are being conquered with almost bewildering rapidity these days. It follows naturally that in the hustle of collecting new data we are less concerned with how we report new findings than with the fact that we have enlightening results to report.

The scientific community, as Major Mannix points out, is the final jury in the matter and any idea proposed must make a significant contribution to even be considered. But it is natural for the scientific community to follow the path of least resistance and to continue using the old familiar terms and units, even when they are clumsy and inappropriate.

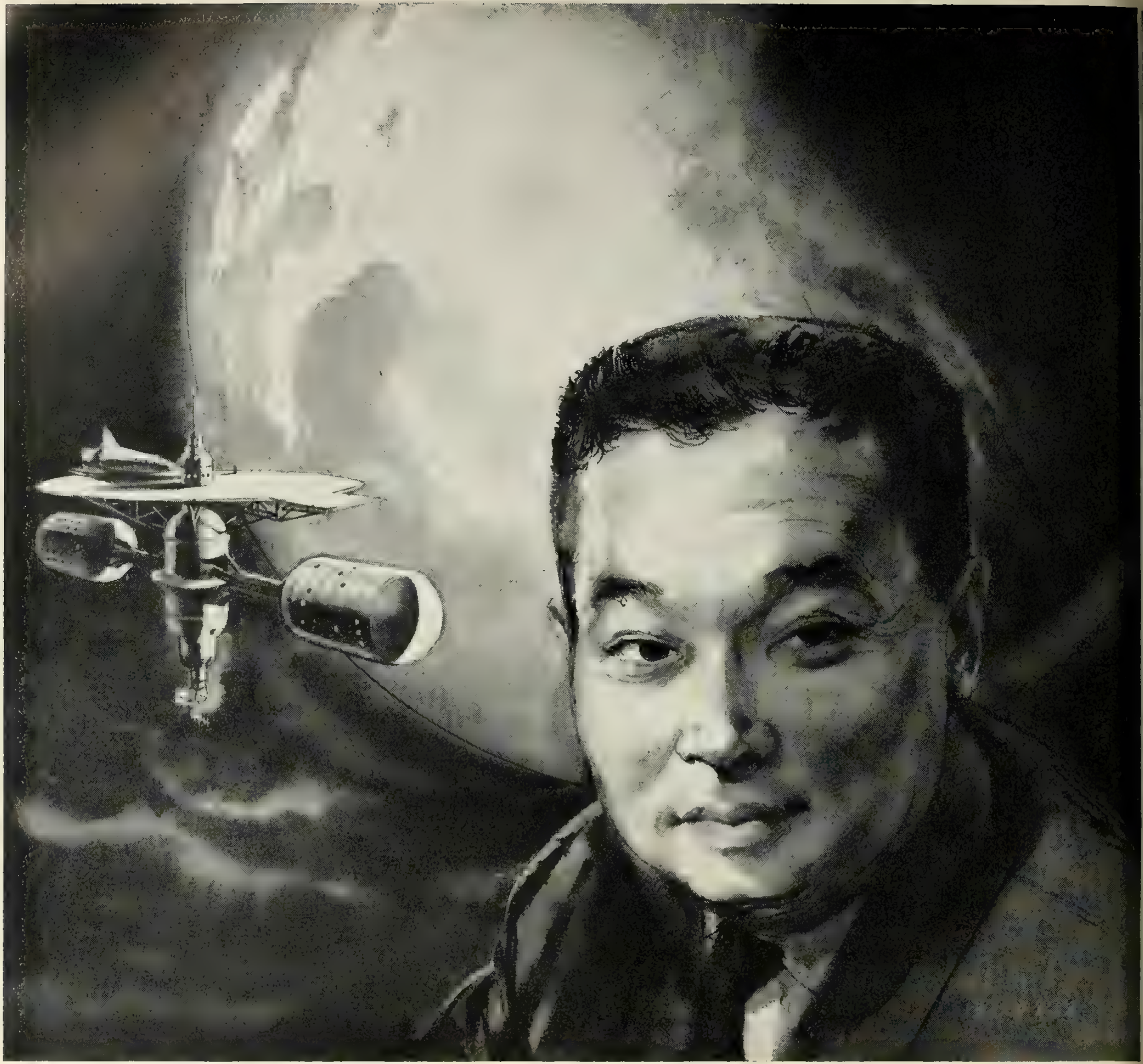
With different investigators using different terms and units in different projects, confusion is inevitable. Worse, as we continue to use the outmoded terms, they will become imbedded in our thinking and in our records. The longer we wait the more difficult and the more expensive any change will be.

Major Mannix believes the scientific community should make a serious effort to standardize logical and convenient terms which will reflect the advances in the relatively new scientific art of astronautics as soon as possible. He cautions, however, that this must be done and done finally only when the state of this art has advanced far enough to outline its boundaries and encompass the territories within.

We believe that there can be no better time than right now to instigate the beginning of such a project. Delay, in the hope that confusion in terms and units will somehow straighten itself out, is pure wishful thinking. World standardization is necessary and even critically necessary.

To that effect, we would like to recommend that one of the international astronautics organizations, such as IAF, take up the project of standardization of velocity terms. It is worthwhile and should have been started some time ago. The goal should be a uniform standard of measurement. Whether it is the Optik or something else is relatively unimportant.

Clarke Newlon



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THE GENERAL TIRE

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washington countdown

IN THE PENTAGON

Defense officials warn that the hardening of ICBM bases will not make them invulnerable forever. They say the day will come when mapping and missile guidance will be so accurate that no amount of hardening will protect ICBM's from being destroyed by multi-megaton warheads.

• • •

Production of U.S. missiles by Western European manufacturers still appears to be a long way ahead. This is true not only of the much-talked-about NATO IRBM but of such smaller tactical missiles as the *Sidewinder* and *Hawk*. One hitch of many is the treaty ban on Western Germany. The ban prohibits the Germans from making missiles without special permission. It could be relaxed by the treaty signers—all members of NATO. But some are reluctant.

• • •

The Defense Department—at least for the present—has met head-on the growing drive in Congress to add hundreds of millions of dollars to the defense budget for ICBM programs—particularly for more *Atlases*. Top defense officials say that if Congress votes the extra money it won't be spent. However, the department is privately reviewing proposals to pump more funds into the ICBM programs after all.

• • •

The Pentagon is taking a ho-hum attitude toward an advance deal made by the seven astronauts to share whatever publication profits they may garner from taking part in the man-in-space program. A Washington lawyer thought up the deal and drew up the contract for the seven airmen. He says his role is strictly non-profit.

ON CAPITOL HILL

The House Armed Services Investigating Subcommittee's inquiry into the weapons system concept of procurement may run longer than expected. Originally the subcommittee expected to end its investigation by late July. Now after two weeks of hearings it looks as if the investigation won't be completed until at least the end of the year. The next two firms at bat: Boeing and Convair.

• • •

A new Special House Space Subcommittee on International Cooperation and Security is considering some on-the-spot inquiries overseas. It may study space activities in Russia, Italy, Great Britain and Japan.

• • •

A number of Congressmen are frowning over a recent turn in NASA's public information policy. Despite vigorous protests from Rep. James G. Fulton (R-Pa.), NASA officials refused to make public at a House Space Committee hearing a complete list of planned unclassified space programs with a tentative calendar. They said they declined as a matter of "public policy" because the information might help the Russians—and they conceded it might prove embarrassing later on, too.

AT NASA

Here is the current lineup of launchings in the Venus probe program: *Thor-Able III* next month into a 150-30,000 mile orbit; *Thor-Able IV* early in June; *Atlas-Able* to Venus; *Atlas-Able IV* shortly afterward also to Venus.

• • •

Thor-Able IV will carry a 78-pound payload. *Atlas-Able IV* will carry a 325-pound payload. However, the whole program may be postponed if the solar battery paddle wheels on *Thor-Able III* fail. The paddle wheel power plant is needed for communications in the Venus probe.

AROUND TOWN

U.S. space experts and many Congressional officials are pressing for early negotiations to either rent or buy the British-owned Christmas Island as an equatorial launch site for satellites.

• • •

A two-day symposium on space research will open at the National Academy of Sciences April 29—not June 29 as previously reported in *M/R*. The symposium—to be attended by top U.S. space experts—will follow the academy's annual meeting.

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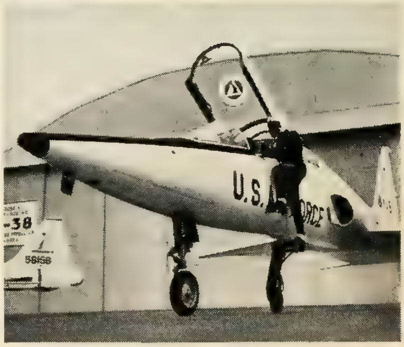

industry countdown

STRUCTURES

ARPA wants $50 million in 1960 FY for *Saturn*—the ABMA space probe which will use cluster of eight *Jupiter* rockets as a 1.3 million pound thrust booster. Rocketdyne is furnishing engines for four *Saturns* and 12 more are programmed. Static firing is scheduled this Fall with first launching attempt a year later. In-house ARPA study is directed at feasibility of recovering the booster cluster for re-use. *Saturn* second stage will be an as-yet undetermined ICBM; third stage a *Centaur,* and possibly there will be a fourth stage.

• • •

Douglas Aircraft reportedly is working on a "hot" new missile. Project is so hot North American projects have to wait whenever Douglas uses its skin millers.

• • •

Look for major changes in ARDC when Maj. Gen. Bernard A. Schriever takes over next month. Insiders feel he will scrap some marginal programs to put more money in others considered critical. Schriever is expected to strive for a more balanced organization with research directed toward advancing a mixed aircraft-missile force.

• • •

Effective May 1: A 3% raise for about 100,000 hourly-paid missile and aircraft employes of Douglas, North American and Lockheed. Raise was included in contracts negotiated last year with AFL-CIO United Auto Workers and Machinists Unions.

• • •

Lt. Gen. Clarence Irvine, retiring April 30 as boss of Air Force procurement, will probably go to work shortly for either North American, Hughes or AVRO—in that order of likelihood. He would like to be on the West Coast.

PROPULSION

NASA plans several more orders of the new *Vanguard* third stage which is produced at the Allegany Ballistic Laboratory—a Navy R&D center run by Hercules Powder Co. Though only two more *Vanguard* shots are scheduled, the ABL engine will be used for the top two stages of *Scout,* and for the top stage of *Atlas-Able* and *Thor-Able.* It may also be put on top of *Pioneer* series and *Centaur* and *Vega.*

• • •

Last 15 minutes of *Thor* countdown is now automatic. Once system locks in at T-15, countdown progresses to firing without possibility for human error. Shut-off comes automatically if something goes wrong. Effort now is to cut the time still further.

• • •

Sweden's Svenska Flygmeter has aircraft rocket booster using jet fuel and hydrogen peroxide. The VR-3 engine developing 5700 pounds of thrust at 65,000 feet has one control lever for stopping, starting and throttling.

ELECTRONICS

"Q" ball is the name of Nortronics attitude sensor to indicate angle of attack and side slip during atmosphere exit and re-entry of the *X-15.* Device is hydraulically actuated sphere which always points directly into relative wind. Pilot gets a visual readout on instrument panel.

• • •

Advanced inertial guidance systems in time are expected to permit "name the crater" accuracy of lunar impact. Dr. J. F. Shea of A. C. Spark Plug predicts the next five years will see inertial systems reduced to one-tenth present size and weight; reliability will improve and they will be able to handle any navigational problem with "hi-fi" or combinatorial systems incorporating stellar-inertial, doppler-inertial and radio inertial.

• • •

Managing NATO's new antisubmarine warfare laboratory at La Spezia, Italy, will be Raytheon Mfg. Co. The lab opening May 2 at the Italian navy base will be directed by Dr. Eugene T. Booth, ASW expert on leave from Columbia University.

ASTROPHYSICS

Measurement of micrometeorite erosion damage to satellite down to 1/100,000 inch may be possible with new technique developed by physicist R. C. Goettelman of Stanford Research Institute. He proposes placing radioactive source inside the satellite, focusing beta rays at the metal skin. A beta ray counter of the backscatter would measure any erosion of metal.

• • •

Rain on the moon? Russian IGY scientific writer F. Zigel predicts that within a century man will succeed with the aid of huge atomic power plants in surrounding the moon with an artificial atmosphere, using chemical elements of the lunar crust to generate nitrogen, oxygen and other gases. Then, says Zigel, "he will create artificial clouds and cause the first rains to fall on its barren surface, and life will flourish."

More about the Missile Week on page 16.

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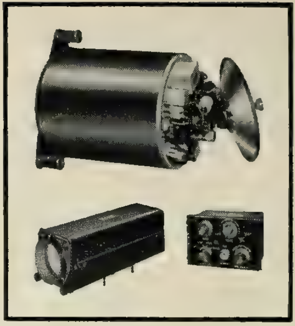

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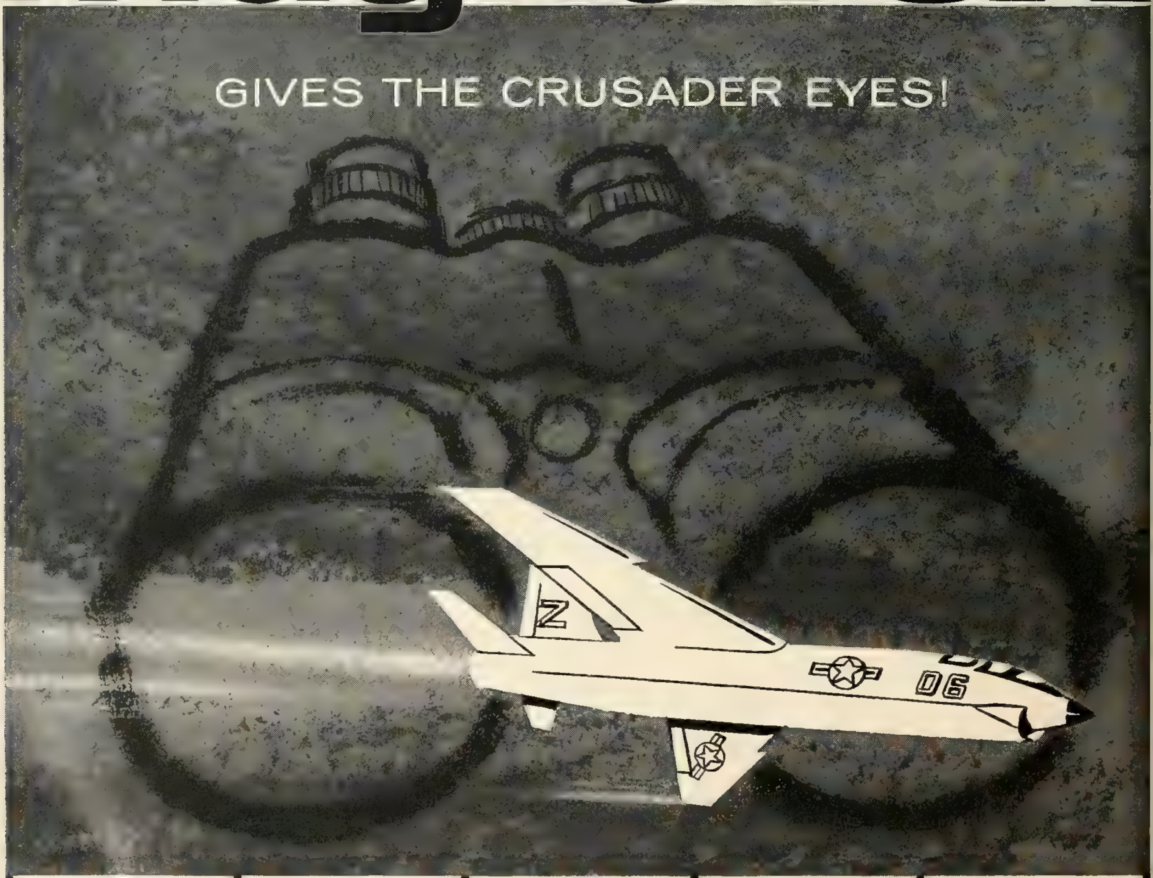

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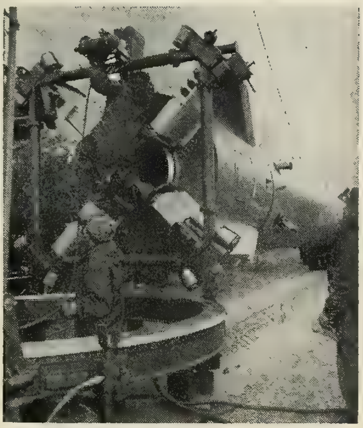
APRIL 27, 1959—VOL. 5, NO. 17



G.I.'s work on *Redstone* in Germany.

NATO Missile Build-Up at Stake

Outcome of East-West conference over Russia's May 27 Berlin ultimatum will effect $1 billion in U.S. missile aid

by James Baar

WASHINGTON—The growing missile power of NATO is certain to be at the heart of forthcoming East-West conferences over Russia's May 27 Berlin ultimatum. Hanging on the outcome are plans of U.S. industry to provide at least $1 billion worth of missiles to NATO forces.

This is the bright blue chip that a number of high-placed Western diplomats want to toss on the negotiating table at Geneva next month.

Few things could make the Russians happier.

Today NATO has less than 22 divisions standing between the Red Army's hordes and the Atlantic. Fail to arm fully all NATO forces with missiles capable of delivering nuclear warheads and their strength compared to the Red Army becomes all but laughable.

Still, when British officials—and some other Western European and American officials as well—talk of possible East-West disengagement in Central Europe or a freezing of the status of forces, it is this missile power that is at stake.

• **The result**—Freezing the status of forces would mean an end to the missile build-up of NATO.

Disengagement would mean making a neutral zone out of Central Europe. It would result in ending the big missile build-up in Western Germany including German cash purchases of missiles in the United States.

Diplomats favoring such plans would seek in return Soviet agreement on some system of East-West inspection and control.

The boost in NATO missile power began only within the last 10 months. Until then only the more than five U.S. divisions in Western Europe, along with U.S. Air Force and Navy units attached to NATO, had so-called advanced weapons—missiles with nuclear warheads.

In all, U.S. Army and Air Force units in Europe last summer had between 20 and 30 missile battalions—all tactical. By now some 10 missile battalions are being put into the hands of non-American NATO forces. By the end of the year non-American NATO forces are scheduled to have more than 35 missile battalions—tactical and strategic.

This means that Gen. Lauris Norstad, NATO commander, will have nearly two-thirds of the 100 missile battalions of all types that he seeks to have by 1963.

• **Breakdown**—Missiles now in the hands of U.S. forces in Europe include:

- Two battalions of 250-mile-range Chrysler *Redstones* in Germany and a third battalion on the way this month.
- Six battalions of 35-mile-range Western Electric *Nike-Ajaxes* (eight launchers to a battalion) in Germany.
- A classified number of 75-mile-range Firestone *Corporals* and 20-mile-range Douglas-Emerson Electric *Honest Johns* in Germany and Italy.
- Three groups of 700-mile-range Martin *Matadors* in Germany. (They are being rapidly replaced with the improved longer-range Martin *Mace*.)

U.S. missiles now in the hands of other NATO forces or scheduled to be by the end of the year include:

- Two to four squadrons of 1500-mile-range Douglas *Thors* in Great Britain.
- Two to possibly four squadrons of 500-mile-range Chrysler *Jupiters* in Italy.
- One group of *Matadors*.
- Nine battalions of *Nike-Ajaxes*.
- Two battalions of *Corporals*.
- Twenty-one battalions of *Honest Johns*.

The tactical-range missiles will be distributed among nine NATO nations: Great Britain, Italy, France, Norway, Denmark, the Netherlands, West Germany, Greece and Turkey.

And much more is on the way.

The United States is trying to complete arrangements with Turkey for installation of IRBM bases there on Russia's exposed southern flank. The IRBM's, which would be manned by the Turks, would be capable of hitting most of European Russia and striking deep into Russia's industrialized Asiatic heartland.

Moreover, the Administration has made clear that present plans call for arming NATO forces with missiles at a continuously accelerated pace.

The Military Assistance Program in the FY 1960 budget alone proposes spending $302 million on missiles for America's allies—mostly NATO nations. Also, $421 million worth of previously authorized missiles are still to be delivered. And hundreds of millions of dollars more are expected to be spent in the next few years.

Besides the missile types already listed, new MAP funds would be spent on 20-mile Martin *Lacrosses*, 20-mile Raytheon *Hawks*, 20-mile Convair *Terriers* and *Tartars*, 7-mile Philco-General Electric *Sidewinders*, guided drones and others.

• **Cash and production**—Nor are all the missiles to be bought with U.S. money. Western Germany—America's best cash missile customer—wants to buy many more missiles of various types including the best of the most advanced. France has been interested in purchasing 1000-mile-range Chance Vought *Reguluses*.

And, finally, a long-range program for developing Western European ability to manufacture missiles is underway.

The first ones would be tactical—such as *Hawks* and *Sidewinders*. But the eventual goal would be production of a second generation NATO IRBM.

Thus, the overall pattern of power in Europe on the eve of the May 27 ultimatum and a probable new Summit Conference is plain.

NATO has less than 22 divisions at combat readiness and about 80 reserve divisions. It has about 5000 planes operating from some 150 airfields. It has more than 1000 combat vessels. The NATO forces are armed with about 40 missile battalions.

But within six months to a year the NATO forces will have more than 60 missile battalions and will ring European Russia with some 100 IRBM's.

Russia has 175 full and partly-full divisions and 20,000 planes that could be used for a lunge across Western Europe. It has more than 400 submarines. Its troops are armed with tactical and medium-range missiles.

However, Norstad has said that he is unimpressed with the size of the Russian forces if his troops can be rapidly armed with missiles carrying nuclear warheads.

This, he said only recently, is his "greatest want."

And he added pointedly: The NATO forces "are not conventional. All of them depend on an atomic capability either within the units themselves or in an atomic weapons system."

Small ALBM May Go on F-105

Republic's Mach 2 fighter may be built in Europe under NATO nations' share plan

by Clarke Newlon

Las Vegas—It is more than probable that several member nations will propose to the NATO Council in Paris that the atomic/missile-capable Republic F-105 all-weather fighter be built in Europe jointly under a "share" plan.

This was revealed during the World Congress of Flight here following remarks by Deputy Assistant Secretary of Defense (Military Assistance Programs) Charles H. Shuff. Speaking at a missile management symposium, Shuff said:

"The ever-diminishing amount of funds available for U.S. assistance and the ever-increasing requirement for U.S. military products necessitates the search for new ways and means to meet these requirements. The military assistance trend is downward. The U.S. cannot afford $2 million per copy for aircraft for her European allies. We can, however, partly pay the cost and we are sure the allies will do their best to share the cost."

Shuff did not allude directly to the F-105 but his cost figure fits the big offensive fighter. His talk also followed closely remarks made in Washington recently by NATO Commander Gen. Lauris Norstad, who said that NATO's greatest need was for modern armament.

The F-105 is a Mach 2 fighter with a combat radius of almost 1000 miles. It can navigate to its target, fire either missiles, cannon or nuclear bombs and return without the pilot ever seeing the ground. While it might be equipped with the *Hound Dog*, it is more likely to carry a smaller version of the *ALBM* now being developed. Such an air-launched missile for the F-105 probably would have a range of some 500 miles, be nuclear-armed and be carried in the bomb bay.

SMALL version of ALBM could be carried in bomb bay of F-105 Thunderchief.

It has been officially announced that the F-105 will soon go to the NATO-committed U.S. units stationed in England, France and Germany. And the European NATO nations now realize that the big fighter fulfills their defensive requirements.

It is understood here that the first requests to the NATO council will come either jointly or severally from Germany, the Netherlands, Belgium and Italy. England and France are aware of the plan but are uncommitted. Both have their own all-weather fighters under consideration, the French Mirage IV and the British TSR-2 (British Tactical Strike Recon), but these are years away from production and would cost as much as the F-105, it was pointed out.

• **How to share**—Under the "share" plan one of the NATO nations would be named as assembly and test manager. Another—Germany for instance—could produce the guidance, another the wings or air frame, and so forth. Britain, which has three engines suitable for the F-105, doubtless would produce the powerplant. These engines are the Rolls Royce Conway, the Bristol Olympus and the de Havilland Gyron. The present F-105 carries the P&W J-75 engine.

It is conceded that under the proposed plan certain parts of the plane, possibly the heavy forgings, would have to be made in this country. These would be handled by Republic and might constitute as much as 25% of the cost—the U.S. contribution to the plan. Republic would also gain by providing technical assistance throughout the life of the aircraft.

Each of the several countries teaming in such a production "share" plan would contribute a portion of the cost and draw planes from the final line in proportion to that contribution. While the sharing of cost is a big item, the fact that it would provide work for aircraft plants of the countries involved is another large factor in the plan. None of the countries who would participate has been able to operate its plants at anything remotely approaching capacity.

Getting a Contract . . .

WASHINGTON—The complexities of contractual relations between customers and the Armed Services sometimes defy description. Occasionally they drive some to distraction, producing bursts of temper or sardonic humor.

In the latter category is the following anonymous document which purports to be a management proposal submitted to the Air Force as part of the routine established for getting a contract. It may be easy for you to identify the company, so M/R has deleted the names. Who knows, you may even work there.

• **General experience**—A detailed reference to the large number of programs which we have mismanaged would be beyond the scope of this proposal (see report 789-2, AF Board of Inquiry; see also report of Congressional Investigating Committee, 1209-A). We feel, however, that the experience gained from these miserable failures puts us in a strong competitive position since it is unlikely that these mistakes will be repeated.

Our competitors may have a greater number of failures, but we would like to point out that our errors were made on larger and more important projects. Furthermore, we have absolutely no experience in the specialty areas required for this design and will therefore approach the problem without prejudice.

• **Organization**—We have reviewed this question carefully and find that we are unable to determine the precise instant of time at which the customer desires to see the organizational structure, and are therefore at a loss as to how to present it. We have investigated the use of high-speed movie cameras and recorders as means of presenting a changing organization, but feel these do not meet the requirements.

We therefore request that the customer specify the moment desired. We suggest that a time during the interval from 0200 to 0700 on a Sunday would be best as experience has shown that the rate of change is at a minimum during this period.

We have found on recent proposals that our key personnel received offers from one of our competitors a few days after the submission of a list of personnel. Since there seems to be evidence of a security leak in the customer's organization, we request that a need-to-know be established before this information is supplied.

• **Technical approach**—Our plan for this project is to hire engineers from the companies which lose the competition. Our technical approach will therefore be determined by these people and can be obtained from our competitors' proposals. We do have a few guiding principles. We have found that on a project of this nature, about 12-18 months are required to catch up with the art. This time is spent in visiting other companies, universities, and test sites and in reading classified reports and *Missiles and Rockets*.

This period is followed by a six-month study phase. At the end of this time it is usually desirable to start traveling again because of the extremely rapid changes that take place in the state-of-the-art.

• **Schedule**—In order to improve the appearance of our proposal the art department has made up a seven-color schedule using stereoscopic plexiglass overlays. The dates in this schedule represent a weighted average between the estimates of the Research and Sales divisions (they are the Sales division figures). In any event, company practice is to terminate a project when the personnel are needed on a new and more profitable contract.

• **Subcontracts**—It is a firm company policy to never let a dollar get out of the house.

• **Cost information**—We do not plan to spend much in engineering. We have found that engineers make changes, and this reduces profits.

Facilities will be a large item. We view this contract as an excellent opportunity to build up our plant.

No charge has been put in since we do not plan to test. In the past, test programs have shown up faults and caused cancellation of contracts years before the mistakes would have been discovered in the field.

The entertainment item was inadvertently omitted from the request for proposal. We have added it.

• **Contract forms and profits**—An exhaustive study will be made during the first six months of the contract to consider these factors. All of the modern techniques of operational analysis, game theory, and high-speed comput-

Do You Follow This Routine?

Great Capabilities

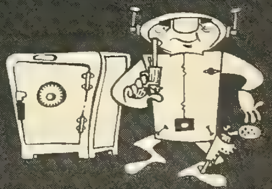
A CHILDS BOOK OF ROCKETS
ABC's of
JULES VERNE
TOY

We have no experience, so will research the problems without prejudice . . .

Great Organization

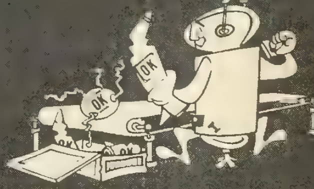
Our key personnel are still with us despite offers from our competitors . . .

Chance For Subs



It is a firm policy to never let a dollar get out of the house . . .

Great Reliability



No testing — tests show faults and cause cancellations years before mistakes would be discovered in the field.

ing will be applied to the problem of profit optimization.

Key points in this study will be legal loopholes, tax dodges, and evasively written clauses. It is expected that several nationally known consultants will be retained for this work due to the overiding importance of the problem.

- **Physical resources**—An excellent survey of our physical facilities is contained in the Receiver's Report prepared during our most recent bankruptcy proceedings. A copy of that report is appended.
- **Additional facilities**—It is our belief that an important project such as this should not be carried out in our shabby plant. We plan to use government-furnished facilities exclusively. We would like to point out that several directors of the company have excellent property which they would be willing to sell to the government for the erection of these facilities.

About the Cover

At the Space Age Conference in Las Vegas, Dr. Edward Teller, famed physicist who directs the University of California's Radiation Laboratory, tossed a mild bomb burst by suggesting a test of Einstein's theory of relativity. It was not his idea alone, Dr. Teller said. He proposed, in briefed-down Tellerese:

"We'll send out, maybe, all kinds of conditions permitting, one of the nice vehicles of ARPA and NASA and put a little nuclear explosive on it, and let it go out a big healthy distance, like, let's say, hundred million miles and then look sharp.

"This thing will explode and send out the whole electromagnetic spectrum from an X-ray through visible to infrared through radar. These will be emitted in a very sharply defined time instant to an accuracy better than a microsecond. Let's see whether all these signals will arrive at precisely the same time. Physics relativity tells us that no matter whether it's X-rays or visible or radar—light velocity is light velocity and we mean it and there is no deviation in vacuum, no deviation of the light velocity whatsoever.

"We'll have the means to check this statement (the theory of relativity) more than a thousand times better than anybody has checked it before."

Others thought all waves would arrive together, if not science will continue to look behind the time differentials.

more about the missile week

Tank-launched *Shillelagh,* lightweight surface-to-surface guided missile designed for close-in troop support, will be developed under $23 million Army contract with Aeronutronic Systems Inc. Raytheon Mfg. Co. will develop the missile's electronic computer fire-control system at its Santa Barbara, Calif., plant.

Polaris test vehicle went more than 300 miles in April 20 firing. Shot was the first considered partially successful after five earlier attempts failed to approach programmed 500-mile objective.

Full-scale mockup of Bell Aircraft *Dyna-Soar* proposal is being examined at Martin Co.'s Baltimore plant by an Air Force evaluation team. Martin and Boeing Airplane head the competitors for design of the man-carrying, boost-glide vehicle. A decision on the winning configuration is expected within a few weeks.

Support for an increase in the Administration's missile budget is gathering in the Senate. Chairman Dennis Chavez (D-N.M.) of the Senate Military Appropriations Subcommittee predicts the funding will be upped, probably in line with the $700 million to $1 billion increase the House is expected to recommend. Chavez' subcommittee begins hearings May 4 on the President's $40.9 billion defense program.

Also on May 4, hearings will be conducted by the Labor Department to determine minimum wage rates in the electron tubes and related products industry. The hearings have no bearing on the pending decision whether the electronics industry is part of the aircraft/missile industry under provisions of the Walsh-Healy public contracts act.

New names: Induction Motors Corp., having moved into large-scale manufacture of electro-mechanical components, is switching its name to IMC Magnetics Corp. The company has just acquired Gray & Kuhn Inc. of Roslyn Heights, L.I. To also make its name more descriptive of what it does, Moog Valve is changing to Moog Servocontrols Inc.

NASA is getting new talent for its Langley Research Center. About 25 scientists and engineers of Canada's Avro Ltd., which recently had its Avro CF-105 interceptor program cancelled, are expected to be hired at Langley.

Inspector General Joseph Kammhuber, chief of the West German Air Force, and a group of Luftwaffe officers, visited Republic's Farmingdale plant last week for a complete demonstration of the F-105 tactical fighter. West Germany would like to acquire the plane under a build-in-Europe "share" plan.

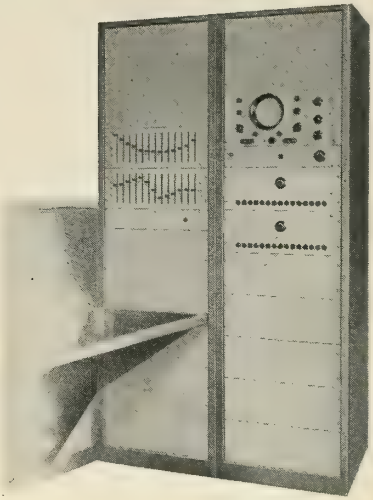
Add silicon carbide foam to list of insulating materials available for missiles and rockets and other uses. Developed by the Carborundum Co.'s R&D division, SCF is self-bonded open cellular structure. A cubic foot of low density weighs 16-18 pounds; high density 30-35 pounds. It provides corrosion-resistant thermal insulation up to 4000°F.

For greater space/missile and petroleum geophysical research, Texas Instruments has formed a new Geo-Sciences and Instrumentation division headed by Fred J. Agnich.

Expansions: CBS-Hytron, which is changing its name to CBS Electronics, on July 1, plans a $5 million, 160,000-square-foot semiconductor plant at Lowell, Mass. Having proved-out pilot production of ammonium perchlorate, Pacific Engineering & Production Co. is expanding its Henderson, Nev., facility to a rated 5 million pound-per-year capacity. Brush Beryllium Co. is adding to its Cleveland Plant and is establishing a fabrication facility and sales office in the San Francisco area. Newport Beach, Calif., location of Aeronutronic Systems Inc., a Ford Motor Co. subsidiary, is being enlarged by 540,000 square feet of new plant space, including more room for the company's Space Technology Division.

Competition for *Titan* all-inertial guidance system has been won by AC Spark Plug Division of General Motors. Based on MIT research, system will utilize liquid bearing gyros. It is reported to be much smaller than the *Thor* system. Work will be done in Milwaukee, with about 50% subcontracted. Arma, which is being replaced in the *Titan* program by AC Spark Plug, has *Atlas* guidance system.

Vibration Testing of New Missiles Saves Money and Time



Trend is toward more accurate reproduction of effects of dynamic forces, using such equipment as Ling's spectral density analyzer system

by Cameron G. Pierce*

Culver City, Calif.—The final test of missile reliability is in the mission. If it takes off, follows its prescribed flight path or trajectory, survives all the environmental hazards, and hits the target area, it is a reliable vehicle.

The entry into space of men and machines presents a host of complex new problems. Advanced techniques such as vibration testing provide opportunities for investigating and solving many of them under controlled conditions during the development period rather than the flight test phase. In both money cost and time cost, such "preflight testing" is most desirable.

Preflight test programs have been instituted with the prime purpose of insuring high missile performance. This is accomplished in part by subjecting it to simulated environments and determining its idiosyncracies with regard to particular flight conditions and factors. Once the missile's sensitivity to these parameters has been determined, effort may be expended in redesign or modification to remove or reduce all adverse reactions.

Shortcomings in the telemetering systems of today leave much to be desired in the way of performance information. Thus, it is of vital importance that as many simulated "flight tests" as possible be performed on the ground before the missile is launched to assure the maximum of reliability. This philosophy dictates the preflight test concept of missiles today.

- **Vibration**—One particular area of environmental factors which is receiving increasing attention is that of vibration. This is concerned with the effect of dynamic forces on the missile elements—forces having amplitudes that vary with time as opposed to static forces which remain essentially constant with time. These dynamic forces may vary from the low-frequency sloshing in fuel and oxidizer tanks, to the high-frequency phenomena associated with engine pulsing and aerodynamic turbulence.

The nature of vibration forces is such that each physical system can exhibit particular sensitivity to certain characteristics of the force. The resulting effect on the system is much more severe than had a force of equal amplitude been applied statically.

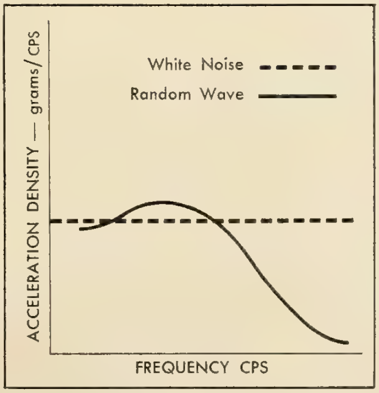


FIG. 1—Power Spectral Density curve.

Vibration testing programs are applied to determine the extent and nature of the system's sensitivity to dynamic forces of various forms. These programs must investigate the effects of all aspects of the force including the amplitude, frequency, time duration, and the various combinations of these parameters. Also, they must subject the missile and its components to forces that are representative of those encountered in operation and provide accurate indication of the system's response to the loading conditions.

- **Dynamic force effects**—No portion of the missile system is exempt from the effects of dynamic forces. Whether these effects result in malfunctioning of the element depends on the degree of sensitivity of the element and the intensity of the force characteristic causing the adverse response.

Structural elements of the missile (and wherever possible, the entire missile) are tested to determine the basic vibration modes of the structure. This data permits the calculation of the dynamic characteristic of the structure and its susceptibility to damage from forces induced by major propulsive and aerodynamics factors. In addition to the effects of these higher-amplitude forces, the missile structure must be tested for

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*President, Ling Electronics, Inc.

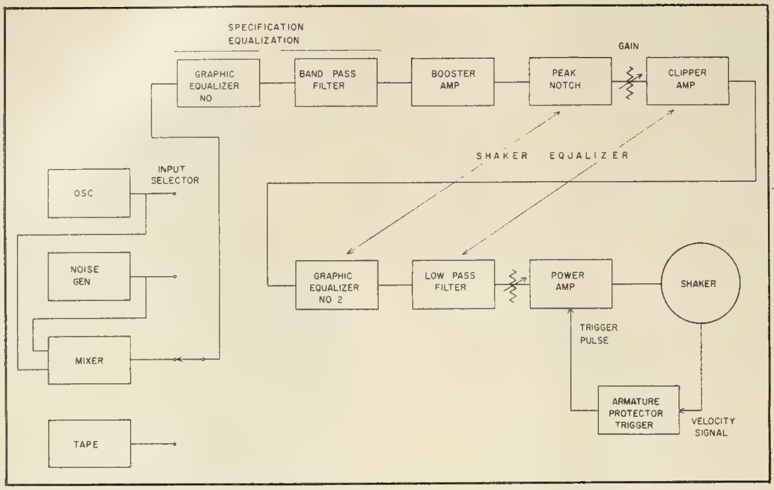


FIG. 2—A functional block diagram of a typical vibration system.

the fatiguing and damaging effects of lower amplitude but multi-frequency forces characteristic of aerodynamic turbulence and powerplant fluctuations.

Closely coupled to the dynamic characteristics of the missile structure are the frequency response characteristics of the missile's control system. Structural oscillations can be picked up by the various dynamic sensors used in the control system. These are often of the proper frequency and phase to result in system instability and destruction of the missile.

Vibration tests applied to the structure-control system combination can insure that the placement of sensors will avoid dangerous pickup of structural vibration. In the case that such placement is not possible, test results can be used to determine the necessary filter characteristics to stabilize the control system in the sensitive range.

Particularly affected by the higher-frequency components of dynamic forces are the fragile elements of the electronic components in the missile system. These components have high natural frequencies which make them very susceptible to the rapidly fluctuating forces. Not only are electronic components subject to actual physical damage, but the forces can cause extraneous and erroneous signals to be generated by the components with drastic results to the missile guidance and control systems.

- **Testing techniques**—Early dynamic force investigations were concentrated on determining the effects of shock loads on structures and components. These studies were begun when it was determined that a suddenly applied force could cause considerably more damage than the same force applied gradually.

In the course of these studies it was discovered that the dynamic characteristics of the structure or component not only determined the nature of the response to these transient forces, but also determined the response to repetitive forces associated with machinery having rotating and reciprocating elements.

These discoveries opened the era of sinusoidal testing wherein the responses of structures, components, and entire systems were determined as functions of the frequency of the applied sinusoidal forces. In most cases linearity was assumed and the effects of complex wave-form were predicted on the basis of a frequency-by-frequency analysis.

Sine wave testing serves its major function in the analysis of the frequency response of control systems and the determination of the vibration modes of the structure. In addition, it is useful in establishing system response to any particular force with a distinct frequency.

Missile studies have revealed the seriousness of dynamic forces with random frequency and amplitude characteristics. These forces were present previously, but were in most cases negligible compared to the effects of shock and sinusoidal loads. Their presence now is more troublesome since they defy the use of linear analysis. The nature of their reaction on missile systems is still cloudy.

One thing is certain: random vibrations arising from multi-frequency aerodynamic turbulence and propulsion system fluctuations are major threats to missile performance and reliability.

- **Random waves**—The prime source of difficulty in the handling of random vibration problems is, of course, the very "randomness" of the forces. Random wave vibrations may be considered as having a finite bandwidth but amplitudes which exhibit statistically random characteristics as a function of time.

As a result, it is impossible to postively describe the amplitude of any of the frequency components at any one time. Rather, statistical analysis is employed to describe the characteristics on a probability basis—that is, the probability that any one amplitude can exist at any one specific instant.

Random wave vibrations can be plotted as a function of frequency by employing the Power Spectral Density curve. This is a plot of amplitude versus frequency, where the amplitude characteristics have been determined statistically. The amplitudes for each frequency are examined and their root-mean-square (rms) value is determined. This is used to determine the acceleration density defined by the following equation:

$$A = \underset{F \to 0}{\text{Limit}} \quad [a^2/F]$$

where:

a is the root-mean-square value of the force,
F is the bandwidth of the force, and
A is the acceleration density in g^2/cps.

The density function plotted versus the frequency spectrum of the loadings is the Power Spectral Density curve. Typical of random wave characteristics is the plot shown in Fig. 1. White noise which has the special characteristic of equal acceleration density at each frequency has the flat curve shown in the figure.

Describing random wave vibration requires that the frequency spectrum and the shape of the Power Spectral Density curve be given. In addition, the total rms vibration level of the spectrum may be determined by the formula:

$$A_{rms} = \sqrt{\sum_{f_1}^{f_2} [A \ \Delta f]}$$

- **Random wave testing**—Requirements for random wave testing have dictated the development of high-performance equipment capable of duplicating the vibration environment with extreme fidelity. This is of the utmost importance because not only must each frequency component be reproduced accurately, but the exact relationships between the components must be maintained.

To accomplish these tasks, provisions must be made in the equipment to compensate for any and all resonances which might influence the final value of force as applied to the system under test. This equalization of the test equipment insures that the system under test is loaded in accordance with the applicable Power Spectral Density curve.

There are certain limitations to the amplitude of loading possible. A Gaussian distribution implies some probability that amplitudes of unlimited value exist. However, the standard working procedure is to provide the system with the capability of furnishing amplitudes equal to three times the rms. This factor is defined as the Crest Factor. A value of three is used since statistically 99.7% of the time the actual forces would have been below three times the rms value.

Since the requirements for random wave testing are far more rigid than those for sine wave testing, test equipment developed for random wave studies is quite adequate for sine wave testing.

Typical Test System

Fig. 2 is a functional block diagram of a typical vibration system incorporating both random wave and sine wave capabilities. Noise generators, sinusoidal signal generators, and magnetic tape reproduction equipment can be the source of the vibration signals.

In a great many instances the vibration environment is composed of sinusoidal forces superimposed on a white noise spectrum. To duplicate this condition an electronic mixer is employed to mix the chosen sinusoidal signal with the output of the noise generator. To insure that the correct relationship is maintained between the two signals, a servo system using feedback signals from the shaker is used to monitor and adjust the amplitude of the sine wave signal generator.

- **Noise output**—The first graphic equalizer and the band pass filter are used to shape the output of the noise generator to the Power Spectral Density specified. This first shaping does not take into consideration any of the effects of the shaker or other elements of the testing system. Development of these graphic equalizers has greatly improved control of spectrum shaping and has reduced the time required in equalizing the system for testing. The equalizers provide amplitude control of the spectrum between 2 and 8000 cps. Each one of a series of attenuators controls the level of a small band of frequencies. Adjusting the positions of the attenuators produces a frequency response curve similar to the physical positions of the attenuators.

A booster amplifier placed after the specifications equalization raises the equalized signal to the level required for further shaping. This is necessary because equalization will have reduced the system gain.

Once the output of the noise generator has been equalized to the test specifications, compensation for the electronic and mechanical characteristics of the test equipment must be provided to produce the desired amplitude characteristics at the shaker table. This compensation cancels the effects of mechanical resonances and loadings in the shaker and the test fixtures.

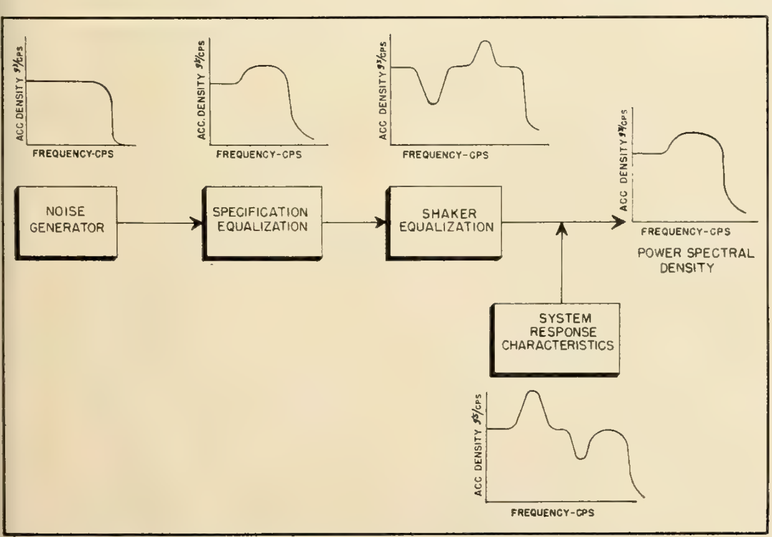


FIG. 3—Steps in shaping required Power Spectral Density characteristics.

To accomplish this system equalization, a combination of graphic equalizers, low pass filters, and peak and notch filters are used. Fig. 3 shows the steps in the equalization process from the output of the noise generator to the required Power Spectral Density characteristics at the shaker.

Peak and notch filters provide vibration test engineers with the capability of placing peaks and notches anywhere in the frequency band from 2 to 5000 cps. These may be characterized by "Q" values of from 0 to 1000 and maintain adjustable heights and depths to 40 db, independent of the "Q" chosen.

The equalization equipment also provides certain safety checks. The clipper amplifier placed after the gain control insures that no signals with amplitudes above a safe range for the shaker are transmitted to the power amplifier. The power amplifier itself is provided with an armature protector which short-circuits and dynamically brakes the armature in the event of instantaneous overcurrent or overtravel.

To insure that the desired acceleration distribution is maintained, a new spectral density analyzer system (developed by Ling Electronics, Inc.), can be used in conjunction with a spectral density equalizer which can be operated with the existing peak-notch filter. Signals from the test specimen instrumentation are fed to a filter analyzer which has a set of narrow-band filters that matches those of the equalizer. Each of the filters has a band pass characteristic identical to the corresponding filter in the equalizer.

The outputs of the analyzer filters are separately and continuously detected and averaged so that the outputs of all the filters may be available simultaneously. An electronic switch samples the "averaged" analyzer outputs and the result is continuously displayed on an oscilloscope as spectral density versus frequency. The presentation is in the form of a series of dots having a vertical position proportional to the average g^2/cps in each incremented band of frequency. Corrections in energy distributions can be made immediately by simple adjustments of the spectral density equalizer attenuators.

High power requirements are necessary to duplicate the vibration environments to which today's missile systems are subjected. Power amplifiers for some vibration tests require 350 kilovolt-amperes to provide peak shaker forces of 70,000 pounds. When missile size and weight factors are prohibitive, portions and individual components of the missile can be shaken.

- **Shaker limitations**—Up to this point in the vibration test system, the elements of the system have all been electronic. However, the shakers themselves are usually electrodynamic, and they present the principal limitation in a vibration test system. Electrodynamic shakers operate on the same principles as do loud speakers. Electronic signals applied to the armature set up magnetic fields about the armature coil which react with the magnetic fields about the field coils. The result is a force tending to move the armature. The armature is connected to the shaker table so that the force applied to the armature is transmitted directly to the table.

The main limitation in shaker performance arises from its physical nature—that is, the shaker must ultimately move a mass. The power required to provide this motion increases both with the mass and the frequency of the signal. However, electrodynamic shakers do provide the most successful means of interpreting electronic signals into mechanical motion with any degree of fidelity and power.

Rugged accelerometers and velocity-sensitive devices are used to monitor the motion of the article being tested, and the shaker table itself. These are usually of the crystal variety which combines sensitivity and good frequency response with a minimum of weight to influence the test. In addition, some instrumentation has been designed to measure displacements by optical means.

Future Developments

As environmental conditions become more severe and missile systems more complex, the trend in vibration testing is toward more accurate reproduction of the conditions the missile will encounter. The reaction of a large and complex missile system to vibration forces can be considerably different from that of any of its parts.

As a result, it will be necessary to increase the test equipment capabilties with regard to the frequency range and the force available at the output. Ideally, each missile system will be tested in a simulated environment duplicating vibration, temperature, pressure, humidity, and other conditions.

Foremost in the efforts to increase test equipment capabilities are developments leading to more efficient and better performing shakers which can withstand other environments such as temperature and altitude. At the same time development work is being directed at new concepts in shaker design and construction.

One new area of endeavor is the use of acoustical testing techniques. In these tests the missile will be vibrated by sound waves generated by high-intensity loud speakers.

This area of testing is becoming increasingly important as the sound levels of rocket engines and aerodynamic turbulence increase to the point that they can physically damage missile structures and components.

Electronic systems currently produced to drive shakers can be readily used to drive these high-intensity sound systems.

Explorer V Will Carry Highly Complex Payload

by Paul Means

WASHINGTON—The payload of *Explorer V*, to be launched sometime this summer, will conduct more scientific experiments in space than any U.S. satellite to date.

The payload will be carried aloft by the Army's *Juno* vehicle, marking the sixth time this vehicle has attempted or put a satellite into orbit and the first time under NASA direction.

Basic purpose of the experiment is to obtain more information about radiation and charged particles in the inosphere in addition to experiments designed to measure micrometeorite density, and the performance of solar cells without micrometeorite shields. NASA project officer is H. E. La Gow of the Beltsville Space Center group.

The vehicle will be sent into a 50-degree inclination low elliptical orbit so that it passes through the inner Van Allen belt.

The top-like design of *Explorer V* aided the fabrication of solar cells into it, and will also help obtain maximum gyro-stabilization with little or no precession. Release of the 20mc antenna spool will retard the vehicle's spin.

The elements of the payload, and their missions, are:

- **Cosmic ray detector**—This instrument consists of two tiny Geiger-Mueller tubes which measure charged particles. One tube is not shielded, and will map both hard and soft components. The shielded tube will detect hard particles only.
- **Lyman Alpha detector**—Photosensitive ion chambers designed to detect Lyman Alpha solar ultra-violet rays at 1216 angstroms.
- **X-Ray detector**—An ionization chamber filled with Argon gas which has a beryllium window and is sensitive to radiation from 15 to 3 angstroms.
- **Heavy nuclei chamber**—An ionization chamber which divides hard particles into three classes: those with masses equal to or greater than the atomic number three, equal to or greater than the atomic number six, and equal to or greater than the atomic number nine. The mass of the particles is measured by the amount of ionization of the Argon gas produced per unit path length in the chamber.
- **Radiation and heat balance experiment**—This will measure the direct radiation of the sun; the fraction which is diffusely reflected by the earth, clouds, and atmosphere; and the fraction which is converted into heat by the earth and reflected back into space in the far infrared portion of the spectrum. Each of the satellite's six sensors are made up of a thermister housed in a hemiphere, two of which are painted black, two white, and two with a special coating which absorbs short wave radiation only.
- **Micro-meteorite density**—A cadmium sulphide evaporated photo conductor that counts the number of times micrometeorites in the order of ten microns and larger hit the sensitive area. The impact makes an opening in the optical opaque film covering allowing sunlight to enter the cell whose resistance is proportional to the area of the opening.

The power supply will be solar cells charging nickel cadmium batteries.

The satellite has no recorder, and ground stations record information only when the satellite passes over.

Quick Photo Service For NASA Satellite

WASHINGTON—Ground equipment monitoring the television cameras in the National Aeronautics and Space Administration's upcoming meteorological satellite experiment will be able to make photographs from the television signals minutes after reception. The ground station receives signals from a miniature magnetic tape recorder in the satellite and immediately re-records the signal on magnetic tape.

NEEDED:

New Velocity Measurement Unit for Space

Is the Optik—based on speed of light—the answer for the confusion in scientific terms?

by Maj. William C. Mannix, USAF*

WASHINGTON—Voltaire stated the proper dictum of the scientist and philosopher: "If you would converse with me, define your terms." With our sudden, serious interest in space operations expanding tremendously, it is paramount that we select and standardize logical and convenient terms and units as soon as practicable.

One goal for standardization is very high-velocity phenomena in space, especially between masses at extreme velocities. Here is an area of fast-moving scientific front lines, temporarily relying on uncertain and clumsy "holdover" terms and units for expression.

We are not only reporting data in a hodgepodge of units, but we have failed thus far to define "hypervelocity," the word most commonly used to describe this area.

The term "hypervelocity" out of context means different things to different people, depending on background. To ordnance experts, something above artillery or machine gun muzzle velocity is implied, possibly 4000 feet per second or greater.

Others in the ballistic missile field think of the word as implying an order of magnitude higher velocity. Finally, still others whose concern is collision with solid debris in space visualize a still higher order of magnitude of velocity. This is a wide range of impact phenomena, probably with several important discontinuities in behavior, to cover with the single term, "hypervelocity."

• **Brackets**—At first glance it looks like a simple matter to put our house in order by subdividing velocities into convenient brackets, and labeling with descriptive terms. We even have a precedent from aerodynamics, as follows:

Subsonic—referring to speeds in air up to Mach .95.

Transonic—Mach .95 to 1.05.

Supersonic—Mach 1.05 to about 5.0.

Hypersonic—Mach 5.0 to 50.

Since this terminology applies to the special case of a body moving relative to a compressible fluid, we can use the root word "velocity" rather than "-sonic" if we wish to show that we refer to the more general case of one body relative to another with gas nonexistent or irrelevant. We should keep in mind that the terms we develop for relative velocity may be used by space trajectorists as well as impact scientists.

It should be noted in passing that "velocity" is a vector term, including both speed and direction, whereas "speed" is a scalar term and the more general of the two. However, general scientific usage seems to favor "velocity," especially when used as a root word. This may be for phonetic reasons, or more likely because it is difficult to dissociate speed from direction in practice. In the terminology proposed later in this article, "speed" can be substituted for "velocity" to fit those cases where a rigorous distinction is needed.

Suppose we were to set up convenient velocity brackets (following the aerodynamic precedent), and label them hypervelocity, supervelocity and so on. For convenience, order-of-magnitude subdivisions are preferable. But we immediately run into a disturbing problem: which units among the several in common use shall we subdivide? We are struck with the lack of consistency that has already developed in the short life of this subscience; it is readily evident, as mentioned earlier, that this stems from the diversity of disciplines represented in this new area.

There is the usual disparity between engineers and physicists on foot-pound-second versus centimeter-gram-second systems, and worse: data on high velocity impact is being gathered and reported in miles/second, kilometers/second, meters/second, and feet/-second; in miles/hour and nautical miles/hour (knots); even in millimeters per micro/second. The very existence of such a mixture of units tempts us to brush them all aside and start afresh. Yet, if we take that step, we must be sure we have chosen an un-

"OPTIK" SYSTEM

Relationship to Other Units of Measurement

VELOCITY RANGE				GUN VELOCITY (1-10 Optiks)	HYPER-VELOCITY (10-100 Optiks)	ULTRA VELOCITY (100 Optik-1 Kiloptic)		COSMIC VELOCITY (10 Kiloptic-1-Megoptik)		
	1 millop-tik	10 millop-tiks	100 millop-tiks	1 optik	10 optiks	100 optiks	1 kilop-tik	10 kilop-tiks	100 kilop-tiks	1 megoptik
METERS/SEC.	0.3	3	30	$3x10^2$	$3x10^3$	$3x10^4$	$3x10^5$	$3x10^6$	$3x10^7$	$3x10^8$ #
FEET/SEC.	0.9843			984.3			984,300			$984.\ 3x10^6$
KILOMETERS/HR. ..	1.080			1080			$108x10^4$			$108x10^7$
MACH (SEA LEVEL)	$81x10^{-5}$			0.81			810			
EINSTEIN (ROEMER)	10^{-9}			10^{-6}			10^{-3}			1

# Approximately the speed of light. Exact value is $2.9979x10^8$ meters per second. Note that earth's escape velocity is 37.27 Optiks.

The author—with an extensive background in weapons research in ARDC, is now with the Assistant for Foreign Developments, under the Deputy Chief for Development, Headquarters, USAF.

deniably superior set of units, lest we only add to the confusion.

• The test—What is a good system of units and measure? There are several tests which can be applied:

a. Natural significance: Is the basic unit directly related to some constant and measurable fact of nature? (This gives us more feel for the significance of measurement and provides a standard for calibration).

b. Numerical convenience: Does the unit system subdivide readily, i.e., progress in orders of tens or twelves?

The decimal system of numbers is not nearly so useful as a duodecimal or "dozenal" system would be, based on 12 instead of 10. The unfortunate choice of 10 no doubt resulted from the number of digits on human hands, a fact important to the thinking of primitive man but unimportant today. The logic of 12 is based on its whole number divisibility by five out of the six lowest numbers, contrasted with three out of the six lowest numbers in the case of 10. This logic is shown by the persistence of 12 as a factor in so many measurements of length, time, circular measure, counting, and so on, in spite of conflict with the decimal system of numbers.

c. Basic unit size: Is the basic (or the working) unit chosen so that we will usually work with reasonably small numbers?

• Good units—Based on these tests, some reasonably good systems of units are as follows: Time units are based on the period of rotation of the earth, and are fairly convenient arithmetically. The meter was related to the earth's circumference (one ten-millionth the distance from equator to pole, now more specifically defined as the length of a particular platinum-iridium bar). The length is convenient, and with decimal divisions and multiples, it provides a system which is as convenient as we can get with the decimal system of numbers.

The gram of mass, as the mass of a cubic centimeter of a readily available and measurable substance (water), and the gram of force, as the pull of the earth on a mass so defined, is the basis for a good system. On the other hand, the foot-pound-second system is a poor one because the basic units lack both natural significance and numerical consistency or convenience.

Regarding velocity units, it follows from the above that feet-per-second and statute miles-per-hour fail the tests suggested. The knot, based on the length of one minute of arc on the earth's surface, has terrestrial significance but none in space. It does not convert readily to either of the most common systems now in use, feet-per-second or meters-per-second. If we must standardize on one of the velocity systems now in use, either meters-per-second of kilometers-per-hour satisfies most of the tests for mundane use. Both possess terrestrial significance, numerical convenience, and magnitude of the working unit which is convenient for everyday use.

• All fail—But what of velocity in space? Unfortunately, all of the unit systems mentioned above fail the tests of significance and magnitude when considered for space usage. Thus, it seems worthwhile to seek a more significant basis for velocity measurement, especially if one can be found which converts readily to at least one of the established systems.

Following a discussion by the author on this subject at the Second Symposium on Hypervelocity Impact Effects in 1957 (jointly sponsored by NRL and ARDC), Messrs. A. Hurlich of Convair and E. B. Bell of the Air Force independently suggested that the velocity of light, expressed in meters-per-second and appropriately subdivided, would provide a good velocity system for space use.

The author concurs wholeheartedly. The velocity of light is constant and measurable; it certainly has natural significance in a grand sense. Through great coincidence (since there is no natural relationship between the size of the earth and the velocity of light) it approximates very closely a round figure in metric linear measure: 3 x 10^8 meters-per-second. Hence a subdivision of the velocity of light, chosen of convenient magnitude, and expressed in meters-per-second, is proposed as the basis for an improved velocity unit system.

• The name?—What should such a unit be called? The concept of velocity, whether expressed by $c = mc^2$ or by $KE = \frac{1}{2}mv^2$, will be more simply and powerfully expressed by a single word without any per-unit-time tag. (Precedents exist in the terms ampere, knot, watt, and other time-dependent units which stand alone.) The "optik" is suggested as a name for the basic working unit, spelled with a "k" to avoid the English-pronunciation ambiguity of the letter "c". The proposed velocity system is outlined in the accompanying chart, giving the relationship of the Optik to various other units.

The exact value of the velocity of light is now considered to be 2.99796 x 10^8 m/s, instead of 3.00 x 10^8. However, the difference is only about one-fifteenth of one percent, which is only a slightly larger error than calling π equal to 3.14 instead of 3.1416, and smaller error than calling the force of gravity 32.2 instead of 32.174.

There is already limited usage of the term "einstein" for the constant "c," the velocity of light; and it has been suggested that the term "roemer" (in honor of the man who first accurately measured this velocity) be used in the same way. In either case, the word "megoptik" clearly signifies that the practical and not the rigorous value is intended.

• What to discard?—A practical question is, "What units can we discard if we adopt the Optik as the working unit in high velocity?" Statute miles per hour is already on the way out, insofar as flight technology is concerned, and should be completely deleted from missile or space travel work.

An intermediate step (which would be an important step forward whether the Optik is adopted or not) is conversion of all high-velocity work to m/s or km/sec as soon as possible.

If this is done, the rest is easy—for the Optik is two things at once: It is a grouping of meters-per-second in "lumps" of 300, for convenience at high velocities, and it is also a simple fraction of the speed of light.

The problem of logical, convenient and universally accepted units is as old as science itself, never completely solved, but nonetheless subject to periodic improvement and enlargement to encompass new horizons. All scientists are aware of the problem, constantly reminded by the inefficient coexistance of cgs and fps systems. As Dr. Hubertus Strughold recently pointed out (M/R, Jan., 1958), "we should bestir ourselves now, while on the threshold of the space age, to systematize our units of measure to avoid further loss of manpower and efficiency from this source."

We are now at a critical point in time such as faced the Ford Motor Company and/or the Society of Automotive Engineers around 50 years ago, when either organization could have led the auto industry (and possibly all U.S. industry) to adopt the metric system. One thing is certain: either changing later or not changing at all to a better system of measure will cost us far more in the long run than the cost of changing now.

Regarding the specific proposals above, the purpose here is to propose some system of velocity units and terms, with both physical significance and numerical convenience, to as wide an audience as practical—for criticism, improvement, or acceptance.

The final jury is the scientific community. Comments on the above proposals, addressed to *Missiles and Rockets* magazine, will be greatly appreciated by the author.

Throttleable Engine Prolongs Aircraft Life

Rocketdyne's AR series with up to 6000-lb. thrust is ready for use although Navy has cancelled program

by Frank G. McGuire

CANOGA PARK, CALIF.—A super-performance, liquid-propellant rocket engine designed to add three years or more to the useful life of fighter/interceptor aircraft has been developed by the Rocketdyne Division of North American Aviation, Inc. The powerplant, designed to be as safe as an automobile engine, uses 90% hydrogen peroxide and JP-4 or JP-5 for its operation.

Rocketdyne has built four versions of the engine: AR-1, AR-2, AR-2-1 and AR-2-2. Only the first is not throttleable, and all have aerial start/stop/-restart capability. The Navy awarded the company a contract in 1955 for development of the series, and only recently cancelled the program because it had dropped the mixed aircraft powerplant concept. However, millions of dollars were spent on the program, and the engine is now ready for use, after qualification.

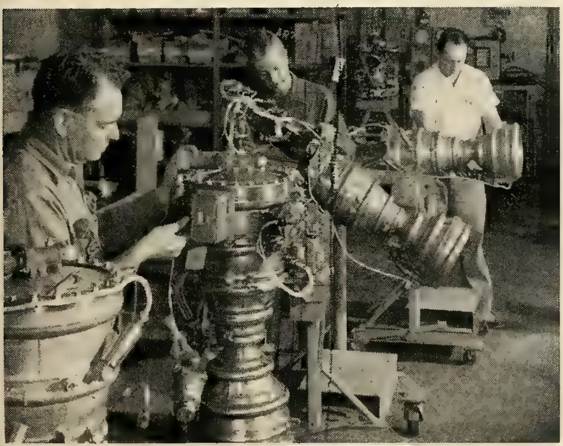
Originally, the AR series was to be used in various fighter/interceptor aircraft to attain super-performance when needed. A number of FJ-4 Fury jet aircraft were converted to the dual powerplant concept, and 103 flights were made using the engine.

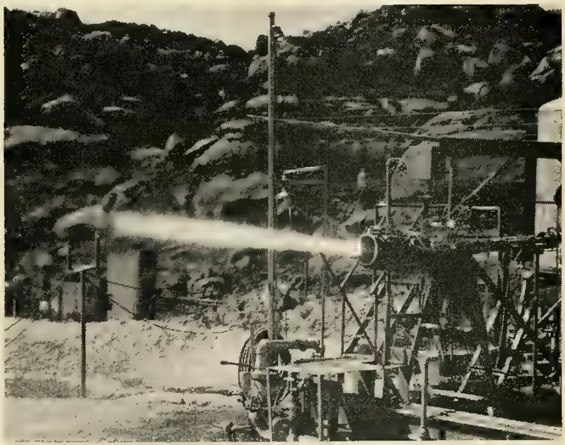
• **Progression**—The first in the series, the AR-1, is a fixed-thrust unit developing 5400 pounds thrust (all thrust ratings given are for the design altitude of 35,000 feet). Some 92 flights were made with the engine in an FJ-4 aircraft, and it was soon decided to modify the engine to provide throttle capability. The fixed-thrust characteristic did not allow the pilot to vary the power as needed, although the AR-1 did have start/stop/restart capability.

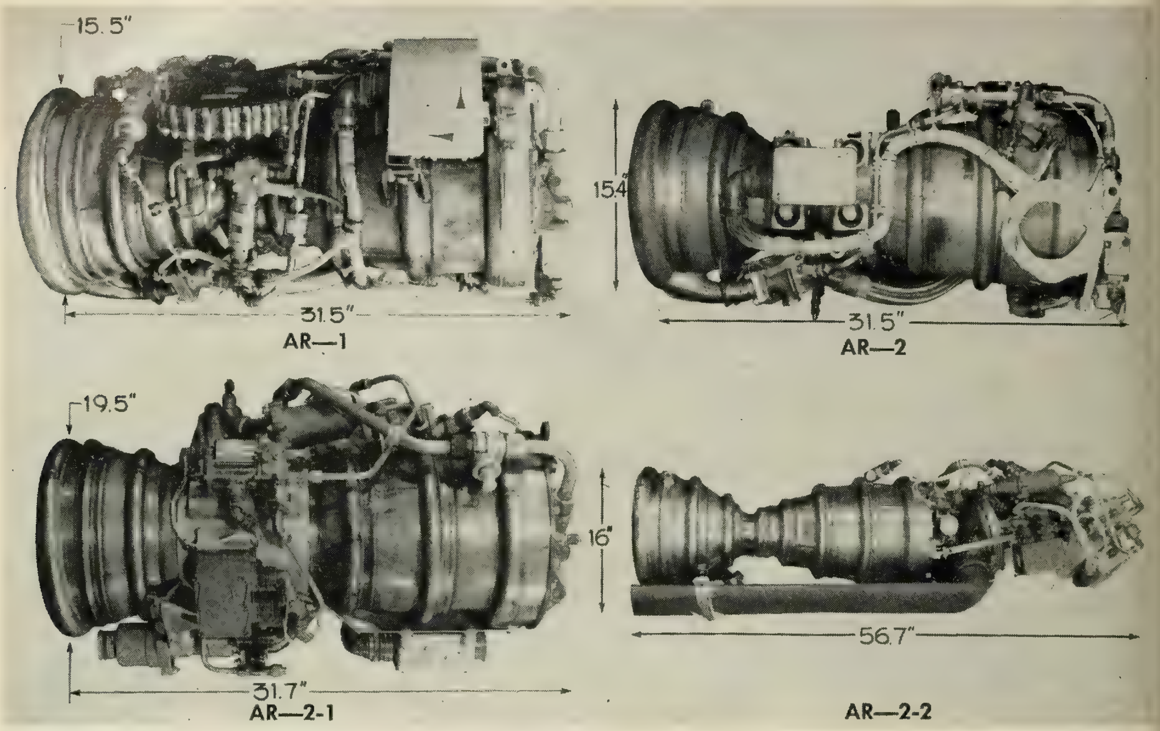
Throttle capability was built into the next engine in the series, the AR-2, enabling the pilot to vary thrust from 3000 to 6000 pounds. Operation time of the AR-1 and AR-2 is three minutes, and the AR-2-1 model is operable for seven minutes. Operation time is limited only by the oxidizer capacity of the aircraft. From the first in the series, the AR-1, to the latest, the AR-2-2, Rocketdyne succeeded in eliminating about 12 components, such as the start tank and other items.

Basic differences in the four models are as follows: The AR-1 has the major drawback of being non-throttleable; the three succeeding models are throttleable and differ mostly in the arrangement of components and mounting equipment. Various sub-units, such as turbopumps, are either grouped around the engine for accommodation in a short space or strung out behind it, for a longer, thinner space.

No structural changes are required in the aircraft, despite greatly improved performance. In the FJ-4 Fury, the climb rate was doubled, the turning radius was decreased, and the speed moved into the supersonic range from a normal subsonic limit. No pitch or yaw effects were encountered when


SHORT but powerful AR-2 liquid engines which were tested on FJ-4F are assembled at Rocketdyne.


USING hydrogen peroxide and JP-series fuel, AR engines undergo static firing.



GOOD EXAMPLE of compact engineering design is this sequence of AR series engines developed by Rocketdyne.

air starts were made. According to Rocketdyne engineers: "There is no comparison between the cost of this AR conversion and the cost of a new Century-Series jet fighter."

• **Test results**—Tests of the engine series showed a very high safety factor. In the AR-1 and AR-2, the running time is three minutes, and preliminary flight rating test (PFRT) required a continuous operation at 35 times the normal length of operation. The AR-1 and AR-2 therefore had to operate for 105 minutes without malfunction. Not one engine failed the test. The AR-2-1 model, with a seven-minute operation time, was tested for 140 minutes continuously, and never failed.

Other tests for the series included 52 malfunction runs, where deliberate malfunctions were provoked to check on damage to the engine. If damage resulted, the offending part was redesigned. Vibration tests were run over a great range of frequencies, with nine hours of operation at 163 cps. Passing the PFRT allows Rocketdyne to install AR series engines in manned test vehicles. Before full production can begin and make the engine a standard item, however, there is a qualification test calling for 300 minutes continuous operation.

The AR-1 engine weighs 240 pounds, and the AR-2 weight has been reduced to 229 pounds. Further reductions are anticipated with the new tubular-wall, stainless-steel thrust chamber expected to reduce overall weight by 50 pounds.

• **Operation details**—Oxidizer capacity for the AR engine in the FJ-4 aircraft was obtained by removing a fuel cell from behind the pilot and replacing it with a bladder-type, kidney-shaped, plastic tank holding three hundred gallons of H_2O_2 suspended from the structural members of the aircraft. The AR engine, burning 100 gallons per minute, was thus limited to three minutes operation in the FJ-4.

The fuel pump which supplies JP-4 or JP-5 to the aircraft turbojet also supplies fuel to the AR engine. The pilot has a switch for the booster pumps, which operate at 25 psi, and can start the rocket engine at any thrust level which he pre-sets with the throttle. The throttle is a rheostat type, sending a signal to a thrust control unit. This signal is matched with one emanating from a thrust-control transducer, which determines chamber pressure and translates it to an electric signal.

If the chamber pressure is too low for the thrust level desired, a signal is transmitted to the gas generator, which produces more output to drive the turbopumps, which in turn provide more fuel and oxidizer to the engine. When chamber pressure rises so that the throttle signal and the thrust-control transducer-signal match, that thrust level is maintained until changed by the pilot.

The gas generator operates with a 16-mesh silver-plated screen to act as a catalyst on the hydrogen peroxide. The H_2O_2 decomposes into superheated steam at 1400°F, when passing through the 2½" diameter screen.

Catalyst screen packs are constructed with alternating silver-plated and stainless steel screen layers so that the steel screen acts to prevent the decomposition temperature of the H_2O_2 from melting the silver and fusing the screen layers together or closing the holes in the mesh. The life span of the screen pack is limited to five operating hours by the silver plating, which must be of a special type for the operation.

Valves are operated under line pressure, not electricity, to provide a higher safety factor. The only electrical connection is a cutoff device preventing the pilot from turning the engine on if a valve is partially open.

• **Oxidizer-cooled** — The double-walled chamber is cooled by the H_2O_2 flow, making it the only Rocketdyne engine cooled by the oxidizer instead of the fuel. Operation of the AR series is on a 7:1 oxidizer/fuel ratio. Since H_2O_2 decomposes at 1400°F and the flash point of JP-4 and JP-5 is about 700°F, there is automatic ignition when the two meet.

H_2O_2 is pumped into the thrust chamber, where it passes through a nine-inch-diameter screen pack similar to that in the gas generator; then the superheated steam is mixed with the fuel coming through the injector head. Combustion is at 5000°F. Large rings encircling the engine are expansion joints in the outer wall to allow it to match the thermal expansion of the inner wall. Chamber pressure is about 500 to 600 psi, depending on the thrust level set by the pilot.

Servicing time on the AR engine series is very short to fit the 28 minute airplane service time. Hydrogen peroxide was chosen for the engine because of safety and handling ease. The multimillion dollar Navy program called for conversion of fleet aircraft carriers in order that they might carry a large H_2O_2 tank to service carrier-based aircraft with AR engines.

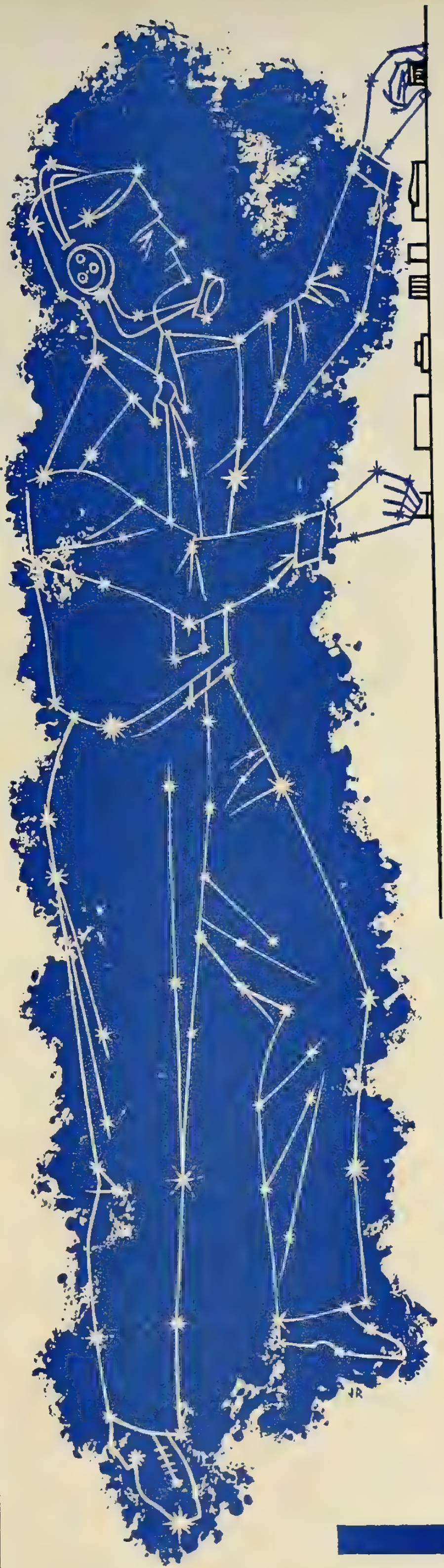
With the new tubular-walled stainless-steel thrust chamber now under development, Rocketdyne expects to boost thrust to 12,000 pounds. The new thrust chamber will also greatly simplify manufacturing methods. The development, however, is not expected to change the Navy's decision to cancel the project.

The decision was apparently made for budgetary reasons, considering the cost of modifying aircraft carriers to handle H_2O_2, and increased emphasis on missile capability, such as in the *Eagle* program, rather than on aircraft. *Eagle* concept calls for slower aircraft.

Bell to Build $20 Million Laboratory

HOLMDEL, N.J.—Bell Telephone Laboratories will build a $20-million modern laboratory here on a 430-acre site for R&D on advanced communications. Occupancy of the first portion of the building will be in late 1961.

Bell has owned the property since 1929 and present buildings provide working space for about 150 scientists, engineers and staff studying high frequency radio and electronics.



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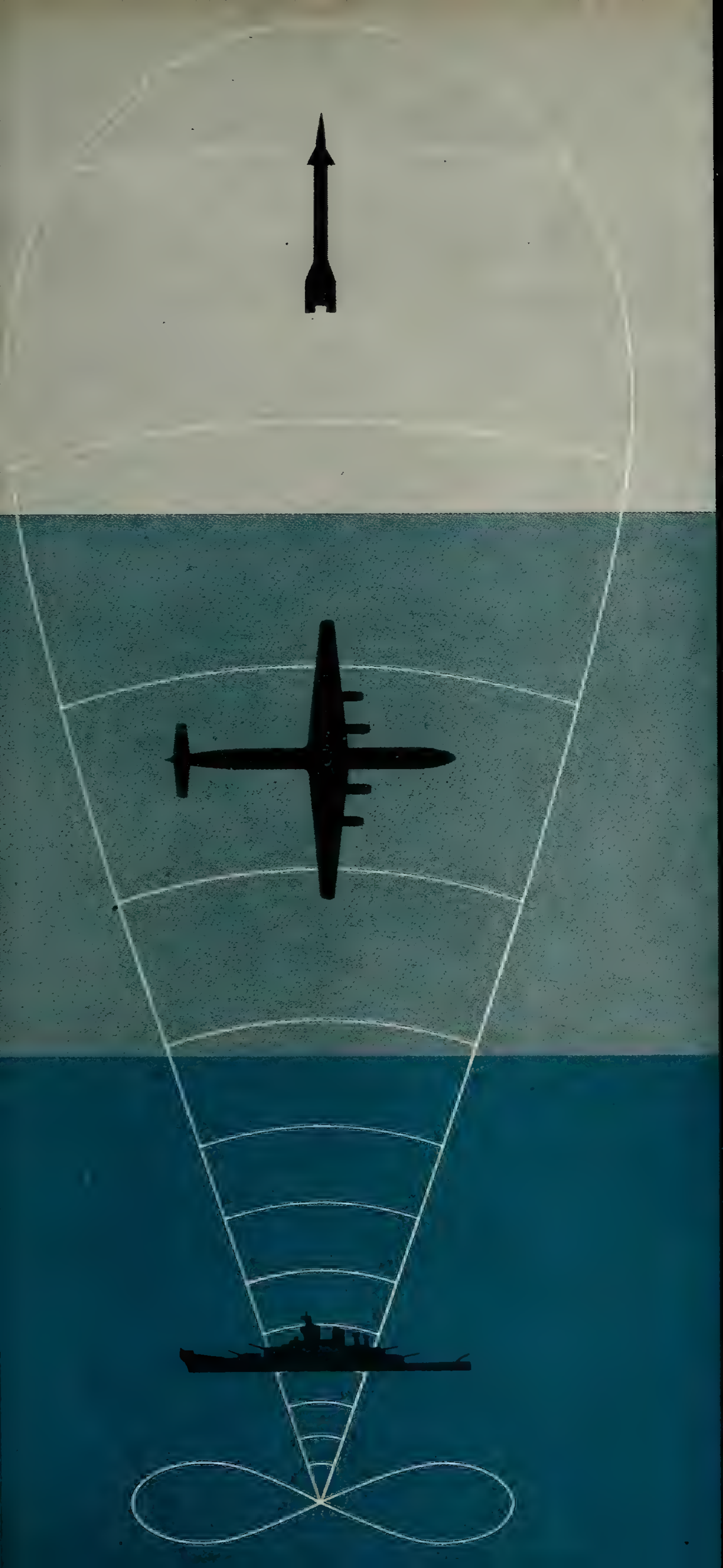

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AF Team Seeks Safer Missile Flights

GMB group is handicapped by sparse data but hopes to develop a central report procedure

by Richard van Osten

LOS ANGELES—Future design and operation of Air Force missiles may be influenced by a small, unpublicized group at Norton AFB, San Bernardino.

Bearing the weighty title of Guided Missiles Branch, Investigation and Field Operations Division, Directorate of Flight Safety Research, Office of the Inspector General, USAF, the 2½-year-old section is tackling the task of missile flight safety. Plans are being made for the day of a full AF missile inventory.

GMB activity is not accurately defined by title. The term "missile" includes all phases of missiles, rockets and drones if a flight endangers life or property, military or civil. At present, GMB is not directly concerned with such AAM's as *Falcon* and *Sidewinder*. These are treated as an integral part of aircraft armament. Nor is there any direct safety responsibility for R&D weapons, although data is being gathered for future use.

Until actual launch, missile safety rests with Ground Safety—a broad activity administered by Deputy Chief of Staff, Personnel. When the button is pushed, GMB interest takes over.

As in most interagency programs, GMB responsibilities are surrounded by a thin line. There is considerable data feedback and interchange from all AF missile and rocket activities.

Organization is patterned after aircraft safety programs pursued by DFSR, whose accident reporting system originally offered little missile application.

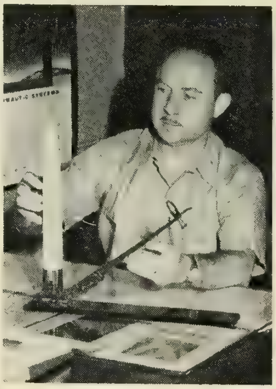
After studying how the system could apply to missiles, GMB obtained a revision of AF Regulation 62-14 to cover missile accidents.

In discussing the group's mission with M/R, Lt. Col. Paul E. Cool, GMB chief, pointed out the program's broad scope and provided a good example of the thin responsibility line.

• **Some problems**—Some difficulty (later corrected) was encountered with early fire control systems. It was possible to inadvertantly fire a missile from an on-ramp aircraft—it had happened. GMB was concerned because it could occur in the air. The revised regulation covers such incidents.

Collection of incident reports remains a problem. The branch reviews daily launching reports from missile test centers for implications of safety problems. Formal reports have been gathered on about 26 missile and mine aircraft-missile mishaps.

This is sparse data, but each report must be dredged as a vital part of future programming so the proper machinery will be ready when needed. A numerical coding system has been devised to pinpoint failure areas and can be applied to longhand forms or coded cards for electronic processing.



Lt. Col. Cool . . . Statistics now—Safety later.

There are two basic report classifications: major mishaps—personnel injury, property damage, or off-range impact—are considered accidents; missile failures in operational units are "incidents." No formal reports are required from R&D units, although GMB would like more than they have received. Additional data inputs are planned in the form of staff reports from other activities.

It is GMB's hope to develop a single report procedure for all agencies. At present, missile units may be required to file as many as five different reports on a single mishap.

• **Overlapping admitted**—Reaction to the program has often prompted the question "Aren't you getting into missile reliability and operational effectiveness?" The answer is "yes," according to Lt. Col. Cool, but only as necessary to build an effective accident prevention program.

When sufficient evaluated data is available, it will become an additional input for missile requirements and perhaps a strong influence in overall planning.

To date, GMB projects have not involved much engineering detail. In a typical example, four Q2 drones impacted off-range in nine months. Many other off-range impacts were prevented only by flight termination through command signals. The resulting investigation recommended study and revision of the center's Q2 operational procedure. In the year since this was accomplished, the center has had no off-range impacts.

The *Matador* was the subject of a similar program when guidance problems appeared in early models. GMB notes, however, that most such weapon difficulties are countered by system improvements almost before the cause can be determined from the scattered reports available.

Limited firings have produced a scarcity of IRBM and ICBM operational data. GMB advocates a system safety review prior to first R&D launch of a production model. This has been conducted on the *Thor*, but there is much effort to make the review a system requirement.

Data concerning missiles powered by engines with AF aircraft histories are coordinated with applicable activities. This area was highlighted when a fuel system modification, badly needed when the engine was used in planes, went unattended in the missile application until it was pointed out that the weapon's operational efficiency (and safety) had been impaired.

• **Only a beginning**—Missile safety training is both necessary and desirable, but GMB has not yet determined program needs. As a starter, DFSR's subject-of-the-month safety program for 1959 includes "Missile Safety" as its target for December.

There is some unofficial thought that to maintain top crew readiness, it may eventually be necessary to launch missiles from sites in metropolitan areas. This could only come after an increase in practice missile allocations. Statistics on crew proficiency are being carefully monitored. Additional firings will mean added production and costs, and it may prove cheaper to fund additional vehicles than risk unskilled launch procedures when they are most needed.

Data is GMB's number one problem. It would like to see improved telemetry systems to better inform operational units. Another problem area is that too few missile activities are aware of GMB and its functions. As a guide to commanders, the group has prepared a "Missile Range Safety Guide" available to all missile activities. The booklet serves also as a door-opener for GMB.

- **Hopeful outlook**—The picture is not too black: in a 10-year period, ARDC has launched 3,685 missiles of various types with one fatality and three serious injuries; ADC, TAC and SAC have good safety records because of serious-minded safety organizations and policies.

The 1958 Worldwide Flying Safety Officer's meeting marked the initial inclusion of GMB in safety problems. High-ranking personnel from most AF commands with missile units presented their views. As a result, the following recommendations were drawn up by GMB. (They are intended as *recommendations only* and do not reflect present or future policy of DFSR or GMB):

1. Direct missile safety efforts, including factory-to-target sequence, from a single staff agency at AF level.
2. Establish Missile Safety Officers in pure missile and staff units. The officers should be a combination of present ground and flying safety officers—specialized and trained in weapon system to which assigned.
3. Authorize missile safety AFSC's (job codes) for identification of training and assignment of personnel. Establish detailed breakdown of various specialities in missile safety and career fields.
4. Develop through AF staff a single mishap format for all staff agencies.
5. Establish training courses for air-launched and ground-launched missile safety; major air commands to determine quantitative requirements; QP-RI personnel to propose curriculum requirements.
6. Make certain revisions in AFR 62-14 for clear delineation between flight safety and ground safety responsibilities.
7. Rewrite AFR 62-14 to separate missile and aircraft requirements.
8. Have major air commands place a requirement on ARDC for safety review of missile going into operational use prior to first R&D launch of production model.
9. Have Deputy Chief of Staff, Development, investigate development and standardization of safety equipment and instrumentation on integrated ranges.
10. Have Deputy Chief of Staff, Development, investigate feasibility of providing simplified data recorder and telemetry system for operational ranges.
11. Have DFSR investigate MATS problem in carrying hazardous missile items.
12. Have DFSR propose to ARDC that safety information be included in missile T.Os.
13. Have major air commands distribute nuclear safety studies to appropriate squadron level.
14. Have major air commands review missile safety check lists for adequacy of safety measures.
15. Have DFSR provide bibliography of material necessary for safety problems on missiles.

Dahlgren Develops Computer

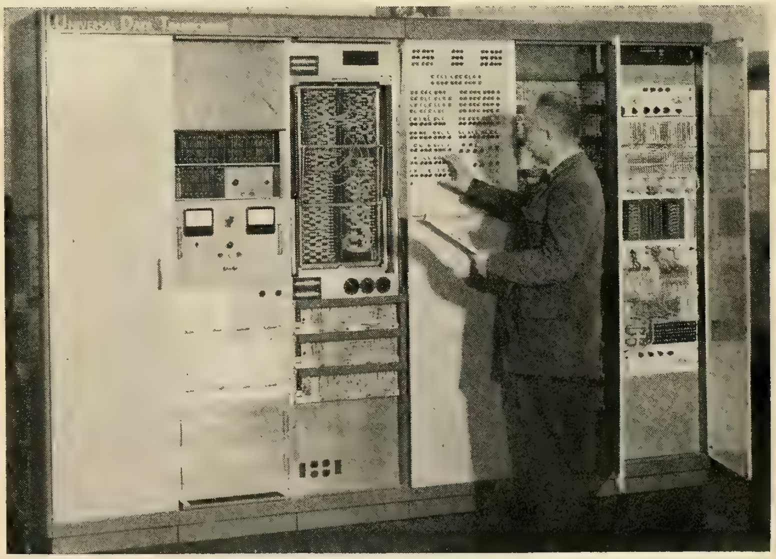
Used for Polaris, machine will handle half-million bits of information each second

WASHINGTON—A model of the Navy's latest contribution to computer technology—the Universal Data Transcriber (UDT)—will be shown for the first time at Andrews AFB on Armed Forces Day. Completed less than a month ago, the UDT is already playing an important part in processing world-wide aiming data for the *Polaris* program.

The transcriber was developed by Dahlgren Naval Proving Ground Computation Center to provide flexible conversion of data between systems previously incompatible because of different formats. Any source of digital data—cards, punched or magnetic tape, etc.—can be converted to any format desired and printed out on tapes, cards, printers, plotters, or other form of digital output. The machine will handle up to a half-million bits of information each second.

Although designed primarily for use with the NORC computer at Dahlgren, the UDT can be used to transcribe data for use with any digital computation equipment. According to Navy engineers, the use of the system will allow the utilization of much data previously "lost" because it could not be economically and quickly translated to fit other systems.

Navy's NORC, said to be the world's leading digital computer, is reportedly three to five times faster than comparable commercial machines.



FIRST DISPLAY of computer will be made at Andrews AFB.

Department of Science: Still 'Iffy'

Hoover-type commission recommended in Congressional hearings to decide how to centralize scattered efforts in science

by Erica M. Karr

WASHINGTON—The Senate Government Operations Committee has wound up the first of two sets of hearings on the question: Should the United States establish a Department of Science. Consensus of most witnesses during the two-day hearings was that something should be done to coordinate the labyrinth of government's scientific efforts starting with a Hoover-type commission to decide what, when and how much.

Most of those favoring a super science agency also suggested that a committee of experts—to include scientists from government and industry—recommend exactly which U.S. scientific functions should be blanketed under the department.

The bill setting up such a Federal agency, to be headed by a Secretary of Science, was introduced jointly by Sens. Hubert H. Humphrey (D-Minn.) and John L. McClellan (D-Ark.).

The measure would coordinate and centralize under one administrative head civilian science functions now scattered in various agencies. A similar though less sweeping measure has been introduced by Sen. Estes Kefauver (D-Tenn.).

Although the Science Department proposal got short Congressional shrift last year, supporters feel the move is inevitable eventually. Said one: "It's coming. It might not be this year, but you can bet your life on it: The United States will have a Department of Science before too long."

• **How it would work**—The Humphrey bill would put under one administrative roof the following: the Atomic Energy Commission, the National Aeronautics and Space Administration, the National Science Foundation, the Bureau of Standards and research functions of the Smithsonian Institution.

All strictly military agencies, such as ARPA, would stay in the Defense Department although there would be liaison with the new civilian department. The status of such Executive Office groups as the Science Advisory Committee would be left to the discretion of the President.

The Commerce Department's Office of Technical Services would be transferred to the department to (1) develop a comprehensive science information program, (2) act as a central clearing house for foreign scientific literature, (3) collate, abstract, translate and disseminate domestic and foreign scientific information, (4) consolidate and coordinate scientific functions of other agencies with the department, (5) supplement and support civilian sources of scientific information.

• **Congressional groups**—In addition to streamlining the government scientific structure, Congress would remodel its own house. The Humphrey bill also calls for a super science committee on each side of Congress to cover astronautics, basic and applied science, atomic energy, and the new Department of Science, with subcommittees for each specific area.

• **More research**—The bill would establish National Institutes of Scientific Research in answer to the "urgent need for a greatly expanded program of scientific research in the United States."

The advantages to industry of a civilian scientific super agency are obvious. There would be one central source for scientific information, letting of contracts and decision-making. One agency would not be able to tie up funds for the project of another agency and leave the contractor caught in the middle, as has happened in the past.

• **Scientific opposition**—Despite the clear benefits to science, some scientists strongly oppose the Science Department idea on two grounds: they fear they would be dictated to by "politicians"—told what was wanted and how to do it—and that a new department, no matter what its scope, would come out on the short end of things moneywise.

Supporters of the new measure say that a Secretary of Science would be one political appointee who could go to bat for scientists more effectively. As for money, it is pointed out Congress has never been so science-minded and—if it follows in its own footsteps of last year—it will try to add to rather than subtract from budget requests.

• **Other questions**—Some of the problems to be considered in creation of a Science Department in addition to which scientific functions now within existing agencies should be blanketed are:

What degree of control or coordination should the new agency exercise in the scientific work of other departments or agencies?

Should it be a purely civilian agency or should it also take on civilian research on military projects?

• **Administration foes** — Although Science Department boosters are riding high on the tide of the times, there is some strong administration opposition. The new Federal Council for Science and Technology created by Presidential order on March 13th was seen as an attempt by Science Advisor Dr. James R. Killian to stall creation of such a department.

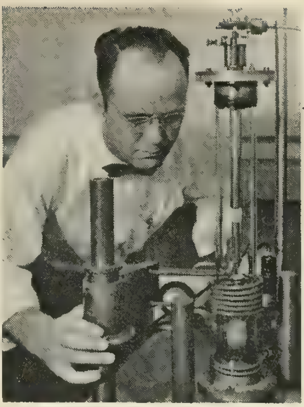
Further, it is pointed out, a good argument can be made that the new scientific organizations have not yet had a chance to prove themselves.

Although there is always resistance to creating another government agency, it is not expected to be strong in this case. Whether enough support can be garnered to push a measure through this year will depend to a large extent on the public support it gets.

One encouraging sign to Science Department pushers: One of the Humphrey bill's four co-sponsors is the junior senator from Texas, Ralph W. Yarborough. Said one legislative expert: "Yarborough is hardly likely to put his name to a measure that he wasn't sure would have the support of Lyndon Johnson (Senate Leader from Texas), and if it's got that, it's in."

"In" in the Senate would still leave a few hurdles.

Sam Rayburn, Speaker of the House, will not commit himself "until I have a chance to study the bill." And biggest question mark of all would be the President, who despite strong opposition from some in his Cabinet, has not yet made his own views known.



Furnace used at the National Bureau of Standards to grow crystals by the Kyropolos technique. The coil surrounding the vacuum chamber provides a temperature sufficient to keep the metal in the small cup molten. As a seed crystal is removed very slowly from the melt, the metal adhering to it reaches the melting point and starts to solidify, forming a large single crystal.

How NBS Researches Semiconductors

Studies include crystal growth, electrical and optical measurements, carrier lifetime, nuclear magnetic resonance, and theory

By Charles D. LaFond

WASHINGTON—With the missile and space industries demanding new electronic solid-state devices, the National Bureau of Standards is carrying out a continuous semiconductor research program to provide more data on the basic properties of materials.

Seven related projects now in progress at the Bureau include research in crystal growth and purification, electrical property measurements, optical measurements, carrier lifetime studies, mechanical and electro-mechanical studies, nuclear magnetic resonance, and development of theory.

Since the discovery of the first transistor—the solid-state triode—in 1948 by Bell Telephone Labs' Bardeen and Brattain, NBS has had a semiconductor research program.

Sponsored in part by the Department of Defense, the NBS solid-state research is aimed toward interpretation of physical properties of matter in terms of microscopic behavior of electrons, nuclei, and lattice vibrations.

During the 1930's the groundwork was laid by Wilson and Sommerfeld for a quantum mechanical theory of electrons in crystals. Born's work on crystal dynamics and Peierls' introduction of the phonon (quantized lattice vibration) concept provided the basis for understanding lattice properties. Toward 1940, solid state physics came into its own.

The materials first investigated on the basis of electron and lattice theories were germanium and silicon. The Bureau became involved in the general effort to arrive at an understanding of semiconducting solids in 1949, when work on the properties of rutile (TiO_2 in one of its crystalline forms) was initiated. These studies eventually resulted in the development of the titanium-dioxide rectifier.

- **Imperfection studies**—Studies of imperfections such as vacancies, interstitials, and dislocations during the last 10 years have made it possible to increase the strength of materials, especially metals. With the growing need for materials to withstand very high and very low temperatures, the results of such studies have found immediate technological application.

In 1952, NBS attention was turned to a new class of materials, the III-V compounds—binaries formed between elements of the III-B and V-B columns of the periodic table. The Bureau is believed to have been the first to undertake research on this group of semiconductors. During the following two years many crystals of aluminum antimonide, gallium antimonide, and indium antimonide were prepared and their electrical and optical properties investigated.

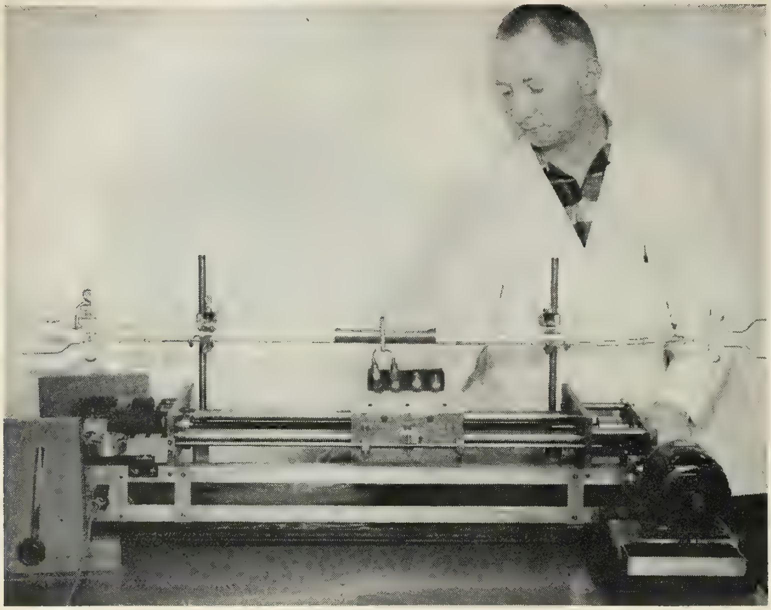
Later on, this research was extended to include studies of mechanical and magnetic behavior. InSb (indium antimonide) was shown to be an extremely interesting material for both basic research and for application to infrared photodetectors and galvanomagnetic devices. Consequently, appreciable effort it still devoted to this material.

Other materials studied during the last five years are magesium-tin and semiconducting gray tin. Recently attention has again been focused on TiO_2 as a result of heightened interest in thermoelectric devices, which has stimulated the study of oxide semiconductors, and especially oxides of the transition metals. Titanium dioxide was chosen as a prototype of this class and also as an example of a high-temperature semiconductor.

Increased activity in solid state research at very low temperatures has more recently produced devices like the maser and the cryotron, a superconductive computer component.

The scope of the NBS program of semiconductor research can be appreciated more readily through the following seven related projects (with some of the results) now in progress at the Bureau:

- **Crystal growth**—Since solid state materials are evaluated on the basis of electron and lattice theories, they must be studied in their crystalline form. Crystal growth and purification have been a vital part of the Bureau's program. Crystals of the III-V compounds are prepared by the Kyropoulos technique. A seed crystal is immersed in a melt and then is slowly removed, forming a large crystal. During the last four years, NBS has grown over 100 crystals of InSb, mostly monocrystal-



AUTOMATIC zone melter is used at the Bureau of Standards to obtain extremely high purity in semiconducting materials. Center: Water-cooled radio-frequency work coil used to melt the solid material to be purified. The coil surrounds a carbon boat which holds the bar of material. The driving motor and the return motor are on the right and left, respectively.

line, by this technique.

To obtain structural information, it is often necessary to have very pure materials or materials with known contamination or doping. Therefore, before the final crystal growth, the crystal-forming substance is purified by the zone melting technique. In the NBS zone melter, the solid material to be purified is placed in a fused silica or carbon boat within a vycor tube. A water-cooled induction coil, concentric with the vycor tube, is then made to pass slowly along the length of the solid material.

The resultant heating effect produces a small molten zone in the bar of material. This moves along the length of the bar with the coil, causing a continuous separation of impurities at the zone boundaries. The separation occurs in such a manner that after the material has been melted a number of times the impurities tend to concentrate at one end of the bar.

Indium antimonide with impurities of only 1 to 10 parts in 10^8 has been obtained with this method. It is also possible to blend evenly a specific amount of another metal to obtain a desired alloy.

• **Electrical measurements** — The first measurements made on each new conducting crystal are of an electrical nature. Conductivity is of primary interest and is determined from the potential drop along a sample of rectangular shape. Additional information is then obtained by studying the Hall effect.

(In 1897, E. H. Hall observed that when a current-carrying conductor is placed in a magnetic field, perpendicular to the current direction, a voltage is developed in a direction perpendicular to both the magnetic field and the conductor current. The Hall coefficient is the constant of proportionality between the voltage produced and the product of the current and field strength. The sign of the Hall coefficient distinguishes between n- and p-type semiconductors.)

A third property investigated is the thermoelectric effect—the voltage between two ends of a specimen kept at different temperatures.

From the variation of these quantities with temperature, information is obtained necessary for an understanding of the mechanism of conduction in the crystal and for evaluating the material for practical electronic use. Measurements of the conductivity, Hall effect, and thermoelectric power are made down to liquid helium temperatures, as are most of the other property measurements on semiconductors. Conductivity and thermoelectric power have been determined up to 1000°C.

Conductivity and Hall effect measurements made at the Bureau on the III-V compounds have shown widely differing properties for this group of materials. Energy gaps range from 3.0 ev to 0.16 ev, and mobilities from 10^2 cm^2/volt-sec to 10^5 cm^2/volt-sec. For some applications, this class of compounds should be very important.

• **Optical measurements—The** employment of semiconductors as infrared photo-detectors requires a better understanding of the principles of the photoconductive process and information on new materials. To provide these data, essential for extending the application and reliability of detectors, the Bureau measures absorption spectra and photoconductivity.

These investigations are carried out as a function of temperature, and interest is focused mainly on the infrared region. Gallium antimonide, cadmium antimonide, indium antimonide and magnesium-tin (having intrinsic absorption edges in the 1 to 7 micron range) have been studied.

Recently an investigation of the photoconductive response of copper-doped InSb showed that fairly large photosignals can be obtained at liquid helium temperatures in the far infrared range up to 35 microns. Interesting quenching effects were found in n-type InSb containing a slight amount of copper impurity.

• **Carrier lifetime**—Carrier lifetime (ζ) is one of the major parameters governing the conduction process in solids. It is defined as the length of time an electron (or hole) takes part in the conduction process before recombining with a hole (or electron) in the valence (or conduction) band.

Its numerical value is therefore of great importance in evaluating materials for application as rectifiers, transistors, and photodetectors. The Bureau has been studying carrier lifetime not only to provide critical values, but to provide a means of investigating the recombination and trapping processes in crystals.

These lifetime values are derived from photoconductivity measurements and the photoelectromagnetic effect. The latter is a kind of Hall effect in which the charge carriers are produced by incident light and deflected in the sample by a magnetic field. The current, perpendicular to both the incident radiation and the field, is proportional to $\nu\,\zeta$, while the photoconductive signal is proportional to ζ. Hence the value of the lifetime is obtained directly from the ratio of the two signals.

- **Mechanical and electromechanical**—The basic nature of semiconductors also is studied by obtaining data on the mechanical properties of crystals. This information is essential for effective material application. This mechanical behavior has been studied by means of several different experiments. Some provide information about the state of the lattice and others indicate the electron assembly. An example of the former is a determination of elastic constants.

These have been measured on single crystals of indium antimonide and the results were correlated with optical and thermal data. So far, it appears that the values of the elastic constants are indicative of the partly ionic character of this compound.

Other experiments depend on the interaction of the lattice structure and the outer electrons. A recent measurement of the resistivity of n- and p-type InSb, under the influence of tensile stress, has confirmed the energy band structure of this material.

The study of internal friction is very well suited to investigations of imperfections. The temperature or frequency dependence of the mechanical damping often reveals relaxation peaks and attenuations, which can be related to dislocations, vacancies, interstitials, chemical impurities, and other irregularities.

Measurements of this kind have been made on InSb up to the melting point (523°C). The experimental method used was the composite oscillator technique in which the sample is driven by a quartz transducer. Similar measurements in TiO_2 are currently in progress.

- **Nuclear magnetic resonance**—Since its discovery 13 years ago, nuclear magnetic resonance has proved to be a very useful technique for studying solids, according to NBS. It has been used to investigate defects and impurities in semiconducting materials. The solid being studied is contained in the coil of a resonant circuit between the poles of an electromagnet.

As the circuit is tuned through its resonant frequency, the nuclei in the sample material move from one orientation to another with a net absorption of energy. The relaxation time—the time nuclei remain in the higher energy state—is measured by pulse equipment.

Initiated in 1956, the technique resulted in the determination of the temperature dependence of the spin-lattice relaxation time in sodium chloride. During the past year, emphasis has been placed on the spin-lattice interaction in aluminum antimonide as deduced from the resonance of the aluminum nuclear spin.

- **Development of theory**—Designed to cover a wide area of physical measurements, the various avenues of experimental work at NBS form a network of closely connected approaches to understanding the electronic and lattice structure of particular solids. At the same time these data are complemented by the formulation of new theories. For example, experimental studies have resulted in a theory for transport phenomena in a strong magnetic field and in a better understanding of the electronic energy-band scheme of TiO_2, containing vacancies or impurities.

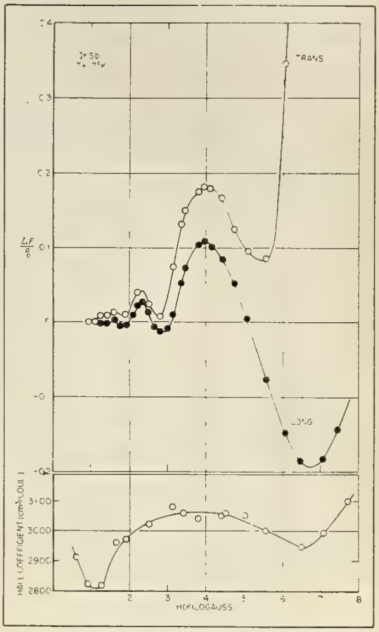
Future NBS research in solid state physics will continue to concentrate on a few materials to provide more complete data and adequate theories to describe observed phenomena. During the coming year the Bureau believes that TiO_2 will receive particular emphasis.

It is hoped that electrical, optical, and magnetic investigations of this material will provide valuable information concerning the role of impurities in the conduction mechanism. By the broad study of a few specific materials, the Bureau intends to continue fulfilling its basic function of supplying materials data and providing a basis for the development of new devices and better engineering materials.

In its electrical property investigations, several phenomena of fundamental importance have been discovered by the NBS researchers. A typical example resulted from a study of InSb. During a measurement of its magneto-resistance as a function of magnetic field H at liquid helium temperature, it was observed that the behavior of InSb was not quadratic in H as expected from classical considerations, but showed several oscillations instead.

These oscillations later were proved to be periodic in 1/H. According to an NBS spokesman, this phenomenon is closely associated with the oscillatory behavior of susceptibility, which has been observed in several metals. Known as the deHaas-Van Alphen effect, it occurs when the electron mean free path becomes a circular orbit.

Then, quantization of the electron orbits must be taken into account; the electronic energy states becomes discrete and produce oscillations in the diamagnetic and transport properties.



UNUSUALLY high magnetoresistance $\Delta P/P_0$ and the Hall coefficient determined by NBS for n-type indium-antimonide at 1.7°K are shown.

SOME TYPICAL crystals studied at the NBS. Left: A crystal of bismuth-telluride; right: three crystals of indium-antimonide.

MODEL is shown of TiO_2 in the crystalline form of rutile. By the addition of foreign ions or the loss of oxygen (light balls), material becomes a semiconductor.

WORLD CONGRESS OF FLIGHT

Famous Photographer Cornell Capa traps spirit of Space Age Conference exclusively for Missiles & Rockets

The first World Congress of Flight was held in Las Vegas where the greatest figures of the entertainment world can be seen and heard for a $3 minimum and where the call of the croupier is never stilled. The Flight Congress ran with clocklike precision and efficiency for distinguished visitors, delegates and newsmen; provided one of the greatest air shows ever seen in this country, and a wealth of technical discussions, and was judged eminently successful—despite pre-convention apprehensions and fears of disapproval from another Congress in Washington.

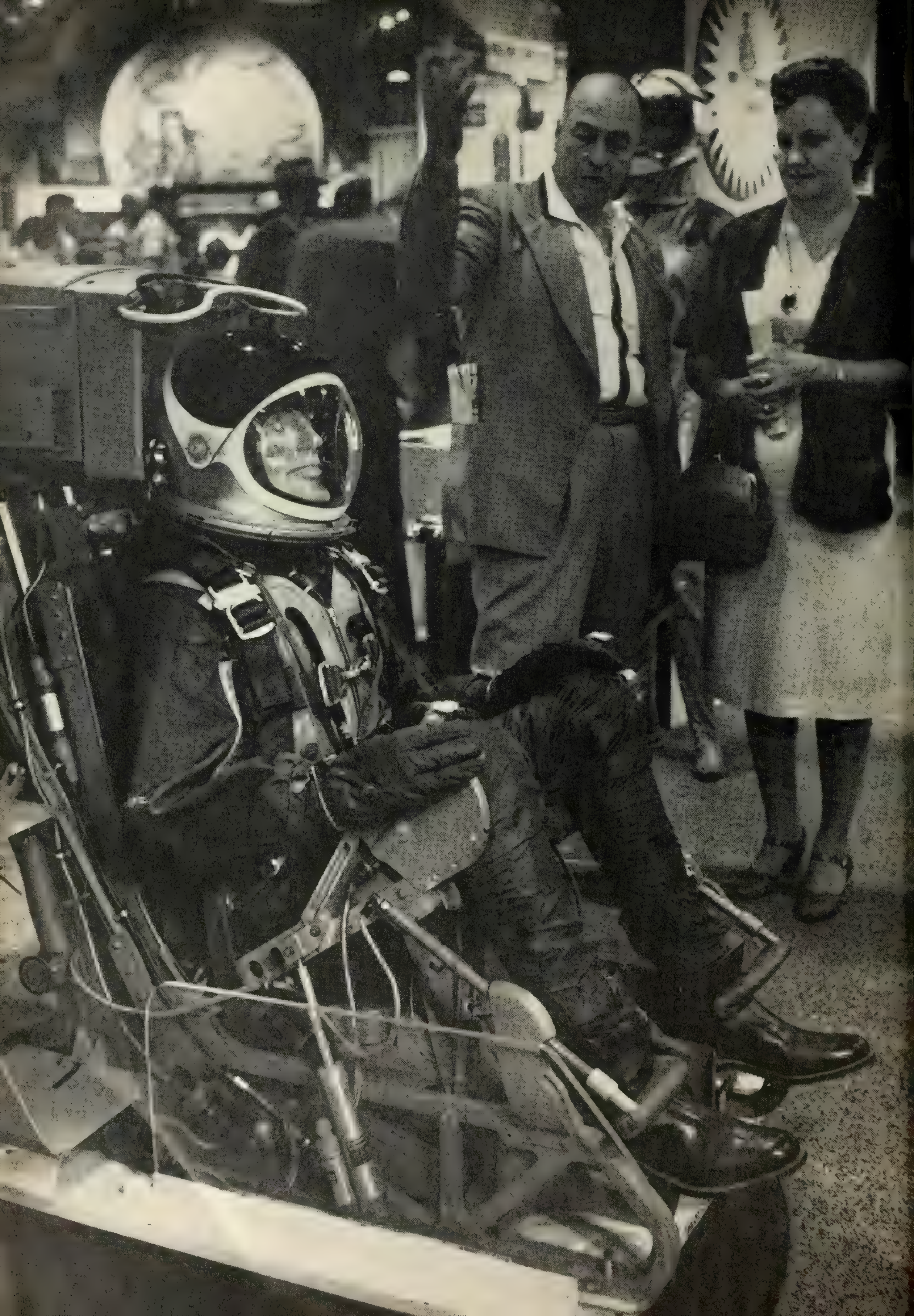
To cover this Space Age symposium, *Missiles and Rockets* engaged a world-famous photographer—Cornell Capa, brother of the late and equally famous Bob Capa—and presents his pictures on the following pages. Cornell is a member of the international Magnum group. He is best known for his work in Life Magazine and his chief interest, he says, is MAN in his various surroundings. In recent months, Cornell has been devoting his time to stories of the Space Age, of which *M/R* will carry more in the future.

WORLD CONGRESS OF FLIGHT was held in the Las Vegas Convention Center, so newly completed that the carpenters were still hammering when the doors opened on the first visitors. Closely grouped on the 100,000 square feet of floor space, delegates saw exhibits ranging from computers to jet engines like the one being inspected above by a member of the Las Vegas western-garbed police.

IN THESE UPTURNED faces Photographer Capa has caught the spirit of the jet age air show. These spectators saw five aerobatic teams, Chinese, Italian, Dutch, U.S., Air Force and Navy, plus a fire power demonstration and fly-bys. The show was held at Indian Springs AFB, some 45 miles from Las Vegas. Local officials solved a transportation problem by declaring a school holiday so 1000 teachers could haul guests in their own automobiles.

AN RED DEVILS, at left, normally flew a four-man team with a
. Here the soloist joins the team to roll by the stands.

THREE GIRLS in Las Vegas costumes pose pistols-drawn before a mock-up of NASA's *Mercury* vehicle, designed to place the first American in space.



SHELTERED BY AN overhanging canopy, the $6-million Convention Center cut to a minimum the normal crowd discomforts, probably will be copied elsewhere.

T OF THE X-15 will be dressed as this dummy (left) appears to convention delegates inspecting model of the rocket craft's seat.

FAMOUS CIGAR in hand, General Curtis LeMay, Air Force vice chief of staff, chats with other visitors in front of the General Electric exhibit.

GLASS IN HAND, Prince Bernhard of the Netherlands chats with Sen. Clair Engle of California (back to camera) at Northrup party on Thunderbird hotel roof.

TWO DIFFERENT HAZARDS to mankind: above, "les girls" of El Rancho's Nouvelle Eve show, below, the Douglas *Genie,* nuclear-packing air-to-air missile.

BACKSTOP PILOT for the *X-15*, North American's Al White in his space suit stands under the profoundly awed gaze of a young admirer while older onlookers show almost equal interest. Note space helmet in White's mittened hand.

EXPANDED RESEARCH

to advance new concepts of SPACE FLIGHT

Expanded Research programs to meet the most complex technological requirements of the Space Age are only one of the far-reaching objectives of the new multi-million-dollar Lockheed Research Center, near Los Angeles. Destined to become one of the nation's major research installations, its programs are broad in scope and designed to investigate new frontiers of space flight.

A primary consideration in planning the new Research Center was to provide environment for scientific freedom and ideal research conditions—using the most advanced equipment available. This modern, integrated research facility will touch almost every aspect of aviation and transportation—leading toward exploration into completely new or relatively undeveloped fields of science and industry.

On completion, most of Lockheed's California Division's research facilities will be located in this single area. The Center will provide complete research facilities in all fields related to both atmospheric and space flight—including propulsion, physiology, aerodynamics and space dynamics; advanced electronics in microwave propagation and infrared; acoustics; mechanical and chemical engineering and plasma/magnetohydrodynamics; thermal electricity; optics; data communications; test and servo-mechanisms.

The first phase of the advanced research building program has already begun—with initial construction of a $5,000,000 supersonic wind tunnel and high-altitude environmental test facilities.

Scientists and engineers of high caliber are invited to take advantage of outstanding career opportunities in this new Lockheed Research Center. Openings now exist for thoroughly qualified personnel in: Electronics; aero and thermo dynamics; propulsion; servo-mechanisms; materials and processes; structures and stress; operations research; research in optics, infrared, acoustics, magnetohydrodynamics, instrumentation, mechanics and hydraulics; mathematics and in all phases of design.

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CALIFORNIA DIVISION
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people

Dr. L. B. Valdes will head Rheem Semiconductor Corp.'s new division for research, development and production of diodes, transistors and other semiconductor devices. The new organization will employ 200 persons by the end of this year and will be housed in a plant soon to be built. Dr. Valdes, who developed one of the first point-contact transistors, has assisted in constructing the first silicon junction transistor and has contributed to the development of various techniques used in the fabrication of semiconductor diodes and transistors.

Four members of the Army's missile-space team have been invited to membership in the new Research Advisory Committee being set up by the National Aeronautics and Space Administration. They are: **Dr. Ernst D. Geissler,** Committee on Missile and Spacecraft Aerodynamics; **Dr. Walter Maeussermann,** Committee on Control, Guidance & Navigation; **Dr. Russell D. Shelton,** Committee on Nuclear Energy Processes, and **Hans Paul,** Committee on Mechanical Power Plant Systems.

Physicist **Dr. Ervin H. Bramhall** has been named chief of weapon systems analysis at Solar Aircraft Co. He previously was systems analyst with the Institute for Defense Analysis. Other posts held by Dr. Bramhall include professor of physics, University of Alaska; physicist-in-charge at the Alaska Geophysical Observatory; operations analyst with the Army Air Force in the Pacific; professor of physics at the University of Hawaii; deputy chief for the Scientific Research Division of the U.S. High Commissioner to Germany, and chief of the physical sciences section of the Research and Development Division, Army Ordnance.

Two new executive assignments at Bell Aircraft Corp. are **Dr. Walter R. Dornberger,** director of engineering of the Niagara Frontier Division, and Vice President **Julius J. Domonkos,** vice president-Manufacturing in Bell's corporate office. Domonkos, formerly manager of the Aircraft Division, will coordinate and direct manufacturing operations in the subsidiaries and operating divisions of Bell Aircraft. Dornberger, who has been technical assistant to the president, will direct all missile, space flight, aircraft and rocket engineering efforts in Bell's Buffalo-Niagara Falls operations.

A. John Gale, vice president and director, applied physics, High Voltage Engineering Corp., will serve on the Research Advisory Committee on Electrical Power Plant Systems of the National Aeronautics and Space Administration. Gale, a recognized authority on ion thrust and other exotic methods for space propulsion, has been associated with HVEC since 1950, first as chief, development division and, since 1956, as director, applied physics. He was appointed vice president in 1958.

An Australian wind tunnel expert, **Dr. Heinz A. Gorges,** has joined the Army

Ballistic Missile Agency under a one-year consultant contract, and will work in the Aeroballistics Laboratory, which operates the missile agency's two wind tunnels. In Australia, Dr. Gorges was principal officer of the Wind Tunnel Group at the Weapons Research Establishment, the base station to Woomera Rocket Range, which is operated jointly by the Australian and British governments. At Huntsville, as in Australia, Dr. Gorges will concentrate on high-speed airflow and its influence on missile design and development.

Frank G. Denison, Aeronautic Systems, Inc.'s new vehicle technology manager, will be responsible for classified military programs underway in the fields of aerodynamics and structures, propulsion research, vehicle components and materials. He will be located in the Aeronutronic Research Center now building in Newport Beach, Calif. For more than 15 years Denison has worked in engineering management programs in the guided missile and related fields.

Rear Adm. John C. Parham, U.S. Navy (Ret.), now heads Motorola's Military Division's Washington office. Adm. Parham joined Motorola in January after retiring as Inspector General of the Bureau of Ordnance. Earlier, he commanded the U.S. Naval Missile Test Facility at White Sands, N.M. Between 1954 and 1956, the Admiral served as Guided Missile Systems Director at the Bureau of Ordnance. His Naval duties also included command of the guided missile testing ship USS Norton.

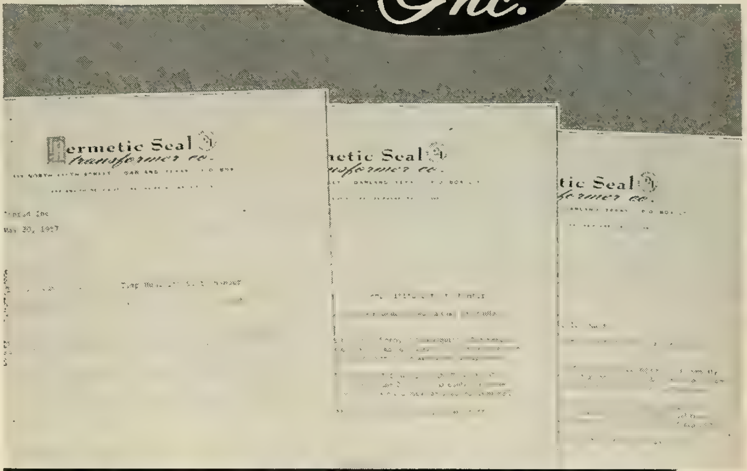
Waste King Corp. has promoted **Boyd T. Marshall** from vice-president-engineering program development to vice-president-general manager of the Technical Products Division. Other Technical Products Division promotions include those of **Frank J. Gallagher** from plant superintendent to chief manufacturing engineer; **Robert Potter** from project engineer to manager-manufacturing services; and **Arthur R. Schneider** to chief engineer. Completing key management positions are **Henry B. Coates,** general plant superintendent, and **Gardner Mason,** manager of quality control.

The appointment of **Charles N. Hood II** as director of engineering for the Airborne Accessories Corp., manufacturers of electro-mechanical equipment for aircraft and missiles, has been announced. Hood was formerly with the General Electric Co.'s Defense Electronics Division.

Hugh Mease, Jr. has been appointed manager, market research and product planning subsection of the General Electric Co.'s Heavy Military Electronics Department.

Lear, Inc. has announced election of **James L. Anast** as president, and **K. Robert Hahn** as executive vice president. **Andrew F. Haiduck** was named to the new post of group vice president.

ENVIRONMENTAL TEST CHAMBERS
FROM THE CONRAD Inc. FILE



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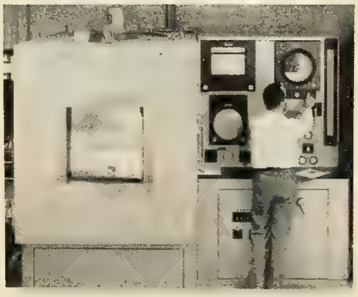

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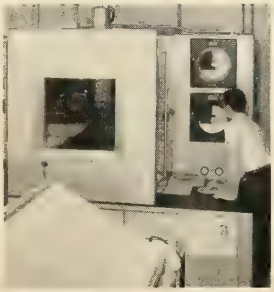

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missile business

by William E. Howard

"Looking more like the automobile business all the time." This is a Washington commentary on today's missile industry trend toward consolidation into relatively few major companies. Creating pressure for more mergers are government weapons system procurement policies which demand greater amounts of cash and more diversified facilities on the part of contractors.

So heavy are the requirements for eligibility that DOD allows small business firms to bid on an average of about 20% of all its "hard goods" prime contracts. In the first half of the 1959 FY, small business actually obtained under 60% of what it could bid on, the Pentagon reports.

The situation is more striking in the award of prime missile and electronic contracts. In the six months ended Dec. 31, DOD says small business—firms with less than 500 employes—won just .9% of $1.8 billion in missile awards and 7.7% of $891 million in electronics contracts. The percentages are almost exactly what they were for the first six months of the 1958 FY, although the dollar volume of awards in the first half of the current fiscal year was *double* what it was for the first six months last year.

Several mergers are in the works. One of the big ones in the talking stage would bring together Central Public Utility Corp.—a holding company with a strong cash position—and Philips Industries Inc., Consolidated Electronics Corp. and Philips Electronics Inc. Texas Instruments Inc. has just combined with Metals & Controls Corp., Attleboro, Mass., reputed to be the nation's largest privately-owned nuclear fuel manufacturer. Negotiations toward a possible merger are being conducted by Thiokol Chemical and Marquardt Aircraft—two leaders in the propulsion field.

Pressure to merge also comes from within the industry—the need to keep abreast of booming technological developments just to stay in business. This requires reinvestment in new plant, research and test facilities at a ravenous rate.

To meet this demand, says Donald W. Douglas, Jr., president of Douglas Aircraft, industry since World War II "has spent more than $2 billion . . . and quite likely will have to invest another billion dollars or more within the next five years." He notes that current costs for building and equipping new plants are running about $36 per sq. ft. against $12 per sq. ft. for World War II plants.

Douglas says: "Add to these factors the reduction in progress payments, increased tightening of procurement regulations, the effects of renegotiation, the increased costs of R&D—including even the preparation of proposals—and the financial problem confronting the industry assumes major proportions."

The younger Douglas was speaking from first-hand acquaintance with the accounting ledgers. His company reported a net loss of $4.2 million for the first quarter of the fiscal year which ended Feb. 28. This compares with net income of $8.5 million for the like period of 1958. Heavy write-offs for its DC-8 jet transport were attributed to the loss.

Douglas doesn't expect a profit for the company's entire fiscal year. The company, incidentally, at its recent stockholder meeting revealed that it generally makes 2% to 3% on military work, while its profit on commercial production can range from a loss to as high as 20% to 30%.

Another stockholder meeting yields the information that Beech Aircraft Corp. is moving into the space field. Beech, principally engaged in private airplane production along with some military work, has landed a $1 million Air Force contract for a "transient heat" laboratory. To be located at Boulder, Colo., the new installation is for ground testing the thermal effects of space flight on prototype rocket and space vehicle propellant systems. Temperatures simulating space conditions will be generated by a system of electric heaters.

contract awards

NASA

WASHINGTON—The National Aeronautics and Space Administration announced award of a $945,000 contract to **Chance Vought Aircraft, Inc.,** for construction of the frame and launcher for the Project *Scout* vehicle.

The Dallas firm will also integrate *Scout's* four solid-rocket stages and send a crew to the Langley Research Center to assemble the rocket for its test flights, scheduled for mid-1960.

Earlier, NASA announced the following awards were made in March:

$4,120,000—**General Electric Co.,** for the second-stage, liquid-propelled rocket engine to be mounted on an *Atlas* as Project *Vega*.
$3,000,000—**Jet Propulsion Laboratory,** for *Vega* integration, payloads and technical project supervision.
$1,070,000—**Bell Aircraft Corp.,** for feasibility study of a high-energy fluorine-liquid hydrogen rocket engine, including paperwork and hardware.
$930,000—**North American Aviation, Inc.,** for destruct system and design of transport vehicles and launcher in Project *Mercury*.
$540,000—**U.S. Army Signal Corps,** for infrared radiation and heat-balance experiment in Project *Tiros*, a classified meteorological satellite experiment transferred from DOD to NASA.
$260,000—**Naval Research Laboratory,** for test equipment for telemetry stations.
$150,000—**U.S. Weather Bureau,** for meteorological analysis in various experiments.
$120,000—**Electro Mechanical Research, Inc.,** for two telemetry systems to build a prototype for use in Project *Mercury*.
$100,000—**Naval Ordnance Test Station,** for R&D on advanced television cameras for advanced space vehicles.
$100,000—**Army Ordnance Missile Command,** for reimbursement for special technical studies and activities.
$80,000—**Cook Electric Co.,** for five free-channel miniature airborne tape recorders for use in various projects.
$60,000—**Thiokol Chemical Corp.,** for *Recruit* rocket motors and high-energy work at Lewis Research Center, Cleveland.
$60,000—**Radioplane Div., Northrop Corp.,** for landing and recovery system for Project *Mercury* capsule.
$50,000—**Herrick L. Johnson, Inc.,** for 3600-gal. liquid hydrogen trailer to be used in support of high-energy rocket work at Lewis.
$20,000—**U.S. Army Ordnance and Cooper Development Co.,** for 10 two-stage *Nike-Asp* sounding rockets.

ARMY

$13,266,720—**California Institute of Technology,** for R&D work at the Jet Propulsion Laboratory.
$5,912,018—**Mattich and Sundt,** Vandenberg AFB, for construction of missile launching complex at Vandenberg.
$3,750,000—**Collins Radio Co.,** for fabrication and installation of one primary and two secondary satellite tracking stations (primary station at existing U.S. base in Spain; secondary stations at Far East sites still to be chosen).
$3,000,000—**Aeronutronic Systems, Inc.,** subsidiary of **Ford Motor Co.,** for development of surface-to-surface *Shillelagh* guided missile. (The figure is for spending on the program in FY 1959; contract eventually is expected to run to $23,000,000.)
$1,842,084—**Douglas Aircraft Co., Inc.,** for *Nike-Hercules* adaption kits, rocket frame components and *Nike* repair parts (three contracts).
$1,500,000—**Freuhauf Trailer Co.,** for a flat bed transporter.
$1,139,569—**The Martin Co.,** Orlando, for work on the *Pershing* system.
$685,970—**Consolidated Western Steel,** Los Angeles, for design, development, fabrication and testing of *Little John* missile motor case assembly.
$554,704—**Chrysler Corp.,** for *Redstone* components.
$532,450—**Leslie Miller, Inc.,** Forth Worth, Tex., for construction of *Atlas* facilities at Warren AFB, Wyo.

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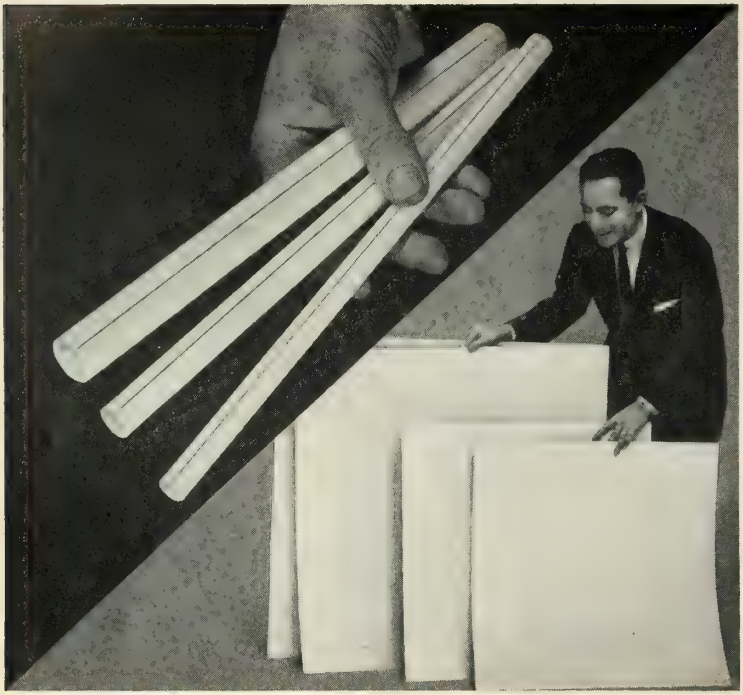

Easy identification in multiple tubing installations is made possible by R/M color-striped thin-wall "Teflon" tubing. Tubing is also available without striping.

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...contracts

$528,501—**Victoreen Instrument Co.**, Cleveland, for vacuum electron tubes (fixed-price contract with price redetermination).

$236,625—**Federal Div., ITT**, Clifton, N.J., for manuscript and illustration for technical manuals on the trailer-mounted guided missile target simulator equipment 1502.

$195,679—**The Firestone Tire & Rubber Co.**, for classified work and for repair and modification of *Corporal* equipment (two contracts).

$187,483—**Autonetics Div., North American Aviation, Inc.**, for design, development and fabrication of a digital analog computer.

$144,050—**Potter Aeronautical Corp.**, Union, N.J., for turbine type flow-meters.

$128,275—**Resdel Engineering Corp.**, Pasadena, for R&D on converter systems.

$101,850—**Indenco Engineers, Inc.**, San Leandro, Calif., for final design of the *Bomarc* facility at Travis AFB.

$78,000—**Rocketdyne Div., North American Aviation, Inc.**, for classified work.

$45,958—**Telemetering Corp. of America**, Sepulveda, Calif., for R&D on a telemetry system.

AIR FORCE

$19,910,782—**International Business Machine Corp.**, for on-site installation, maintenance and logistic support services of SAGE computer systems at various Air Defense Sector Sites for FY 1959.

$2,250,000—**American Car and Foundry Div., ACF Industries, Inc.**, for continued production of mobile launchers for *Snark* ICBM's.

$1,000,000—**Beech Aircraft Corp.**, for construction of a "transient heat" laboratory at Boulder, Colo., for ground testing effect of high temperature on prototype rocket and space vehicle propellant systems.

$1,000,000—**National Company, Inc.**, Malden, Mass., for Atomichron stable frequency standards for ICBM's.

$750,000—**Military Field Services Div., Buroughs Corp.**, for technical non-personal services for on-site maintenance and instruction for the AN/FST-2 coordinate data transmitter.

$664,849—**Gilfillan Bros.**, for moving target reflector sets.

(**The Siegler Corp.**, Los Angeles, announced receipt of a contract totaling almost one-half million dollars from the **Hallamore Electronics Division** for modification of special mobile test trailers for the *Atlas* program.)

$167,452—**Defense Electronics Div., General Electric Co.**, for telemetric data monitors, demultiplexer groups and multiplexer groups.

$124,020—**Litton Industries of Md., Inc.**, College Park, Md., for antennas.

$99,065—**Philco Corp.**, for research on monocrystalline semiconductor films.

$70,000—**RCA Laboratories, David Sarnoff Research Center**, Princeton, N.J., for research on unipolar control devices.

$64,500—**Intercontinental Electronics Corp.**, Mineola, N.Y., for TI-440 radar-to-television scan conversion system.

$50,000—**Western Reserve University**, Cleveland, for continuation of research on orbital electron capture by nuclei.

$49,950—**Horizons, Inc.**, Cleveland, for research directed toward investigations of ferroelectric memory devices and systems.

$40,018—**Ball Bros. Research Corp.**, Boulder, Colo., for research toward development, test and fabrication of sun-azimuth pointing platform.

NAVY

$216,990—**Montrose Div., Bendix Aviation Corp.**, for synchros.

$82,897—**Globe Industries, Inc.**, Dayton, Ohio, for timers.

$55,500—**S. S. Hunter, Inc.**, Syosset, N.Y., for pneumatic guided missile test sets.

$52,990—**American Construction Co., Ltd.**, Honolulu, for guided missile support facility at U.S. Marine Corps Air Station, Kaneohe, Oahu, T.H.

$43,815—**Nems-Clarke Co.**, Silver Spring, Md., division of **Vitro Corp. of America**, for range operation equipment, receiving radio, spectrum display unit, etc.

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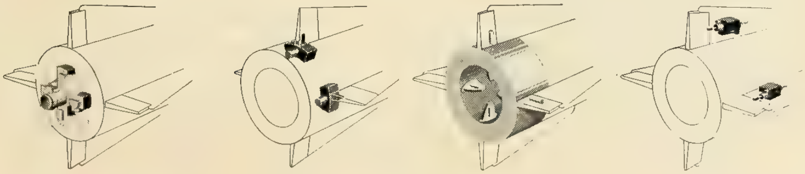

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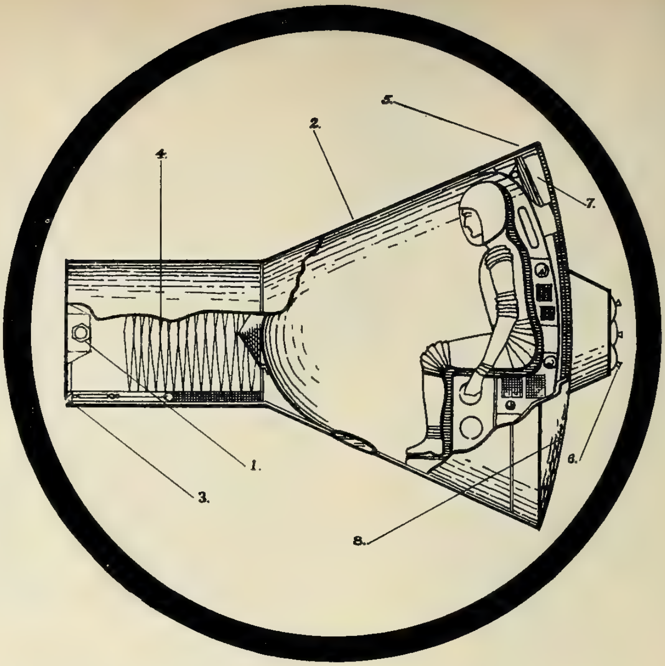

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NASA National Aeronautics and Space Administration

propulsion engineering

Ammonium nitrate as a rocket engine oxidizer decomposes differently than AN as a molten laboratory liquid. Aerojet-General chemists indicate this may change many old views of how this oxidizer operates. They point out that many studies have been made of how ammonium nitrate is decomposed by heat. However, these studies have been made on the molten salt and show that water and N_2O are the primary products. However, AN heated at a solid surface produces primarily nitric acid (vapor) and ammonia. This, they emphasize, is the reaction that takes place as the result of rapid heating, such as burning in an engine. Further, their studies indicate that the rate-controlling process of AN thermal decomposition takes place at the surface layer only. The work was done in Aerojet's Chemical Division at Azusa for Wright Air Development Command.

Fluorine is not yet a practical oxidizer, NASA propellant bosses say. They point out that fluorine can be handled fairly easily as a gas, thanks to recent developments. However, NASA needs it as a liquid, and this cannot be handled routinely. Fluorcarbon plastics are suitable for use as seals and gaskets in systems handling the gas. These plastics also are compatible with the liquid under laboratory conditions, NASA says. But they rapidly break down when operating conditions such as friction and pressure are introduced.

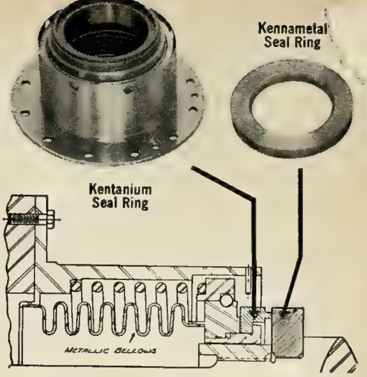
Titanium's corrosion resistance is markedly increased by the addition of trace amounts of palladium and other noble metals. Union Carbide Metals reports that 0.1% of palladium increases titanium's ability to ward off corrosion by 98%. Up to as much as 0.2% palladium will not affect titanium's characteristics, except for increased corrosion resistance. Union Carbide Metals says the Ti-Pd alloys will be reasonably cheap—it costs only 28 cents to add the right amount of palladium to a pound of titanium. The most effective alloy with a noble metal, the company says, is titanium-tantalum. However, this almost absolutely-corrosion-resistant combination will be too expensive for general use. UCM says it will license its Ti-noble metal alloying process to present titanium producers.

Ethers will lubricate nuclear engines and turbojets before very long. W. C. Hammann, Monsanto Chemical, and E. R. Barnum, Shell Development, say polyphenyl ethers are the answer to lubricating problems around 400°F. Actually, decomposition of many of the ethers takes place around 850°F, they say. Some polyphenyl ethers have useful lives of 20-80 hours at 900°F. Also, they told a national meeting of the American Chemical Society, these ethers are two to five times more resistant to breakdown under nuclear radiation than present lubes. But, there is a catch: Many of the engines that can take advantage of these lubricants still are on the drawing boards.

Nuclear engine research soon will center on NASA's two new experimental heat transfer loops. Work so far has been limited to sodium, potassium, sodium hydroxide, and NaK (sodium-potassium) loops. NASA's two new loops will use rubidium and cesium, operate at 1200-1500° F.

Hypergolic propellants don't interest one top NASA propulsion expert. These fuel-oxidant combinations that ignite automatically when mixed have been billed as solving high-altitude ignition problems. However, a NASA propellant authority says he feels ignition system troubles are on the way to being solved, and hypergolics may not be needed.

Premixed ozone and combustible gases can be burned in pure ozone, Army research indicates. Hydrogen, cyanogen and methane can be mixed with ozone without explosion, the Army reports.



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For more information, send for Booklet B-111A, "Characteristics of Kennametal." Write to KENNAMETAL INC., Department MR, Latrobe, Penna.

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APRIL

Aero Medical Association, 13th Annual Meeting, Statler Hilton Hotel, Los Angeles, Apr. 27-29.

American Society of Mechanical Engineers, First National Metals Engineering Conference, Hotel Sheraton-Ten Eyck, Albany, N.Y., Apr. 29-May 1.

American Rocket Society, Controllable Satellite Conference, Massachusetts Institute of Technology, Cambridge, Apr. 30-May 1.

MAY

Air Force Office Scientific Research/-Chemistry Div. and Electromechanical Society, Symposium on Electrode Processes, Philadelphia, May 3-7.

Institute of Radio Engineers, 11th National Aeronautical Electronics Conference, Dayton, Ohio, May 4-6.

Instrument Society of America, 5th National Instrumentation Flight Test Symposium, Olympic Hotel, Seattle, May 4-8.

International Scientific Radio Union, Spring Meeting, Willard Hotel, Washington, D.C., May 5-7.

1959 Electronic Components Conference, Benjamin Franklin Hotel, Philadelphia, May 6-8.

Institute of Radio Engineers, Seventh Regional Conference and Trade Show, University of New Mexico, Albuquerque, May 6-8.

Armed Forces Day, Observances scheduled throughout week of May 9-17.

Aviation Writers Association, 21st Annual Meeting and News Conference, Washington and Willard Hotels, Washington, D.C., May 10-16.

The Atomic Energy Commission, Technical Information Meeting on Test Reactors, National Reactor Testing Station, Idaho Falls, Idaho, May 13-15.

Society of Aircraft Materials and Processing Engineering-Eastern Div., Spring Meeting, Hotel Statler, New York City, May 15.

Space Medicine Electronics Symposium, Franklin Institute, Philadelphia, May 18.

Society of Aeronautical Weight Engineers, 18th Annual National Conference, Hotel Henry Grady, Atlanta, May 18-24.

The Society for Experimental Stress Analysis, 1959 National Spring Meeting, Sheraton Park Hotel, Washington, D.C., May 20-22.

Instrument Society of America, 1959 Ohio Valley Instrument and Automation Exhibit and Symposium, Cincinnati Section, Music Hall, Cincinnati, May 21-22.

Institute of Electrical Engineers, The Radio and Telecommunication Section, International Transistor Exhibition and Convention, Earl's Court, London, May 21-27.

American Rocket Society, Institute of the Aeronautical Sciences, American Institute of Electrical Engineers and the Instrument Society of America, "Investigation of Space" Conference, Brown Palace and Cosmopolitan Hotel, Denver, May 25-27.

American Society of Mechanical Engineers, Design Engineering Show and Conference, Convention Hall, Philadelphia, May 25-28.

The Institute of the Aeronautical Sciences, San Diego Section, Regional Meeting on Supersonic Transports, San Diego, May 26-28.

Federation Aeronautique Internationale, Annual Conference, Moscow, May 28-31.

JUNE

Institute of Radio Engineers' Professional Group on Microwave Theory & Techniques, National Symposium, Harvard University, Cambridge, Mass., June 1-3.

Institute of Radio Engineers' Professional Group on Production Techniques, Third National Conference, Villa Hotel, San Mateo, Calif., June 4-5.

The Pennsylvania State University's Missiles Systems Engineering Seminar, University Park, Pa., June 7-13.

Aero Club of Michigan, Industry Missile and Space Conference, Sheraton-Cadillac Hotel, Detroit, June 8-9.

American Rocket Society, Semiannual Meeting, El Cortez Hotel, San Diego, June 8-11.

United Nations Educational, Scientific and Cultural Organization, Paris, June 15-20.

Cornell University Industry Engineering Seminars, Cornell University, Ithaca, N.Y., June 16-19.

Institute for Practical Research on Operations, Chief of Research and Development, U.S. Army, The University of Connecticut, Storrs, June 21-July 3.

American Institute of Electrical Engineers, Air Transportation Conference, Olympic Hotel, Seattle, June 21-26.

JULY

Tenth Annual Basic Statistical Quality Institute, Chief of Research and Development, U.S. Army, University of Connecticut, Storrs, July 12-24.

Second Annual Institute on Missile Technology, Chief of Research and Development, U.S. Army, University of Connecticut, Storrs, July 26-Aug. 7.

AUGUST

Institute of Investigation of Biological Sciences, Sponsors: Air Force Office of Scientific Research, Aeromedical Div., World Health Organization and United Nations Educational, Scientific and Cultural Organization. Montevideo, Uruguay, Aug. 2-7.

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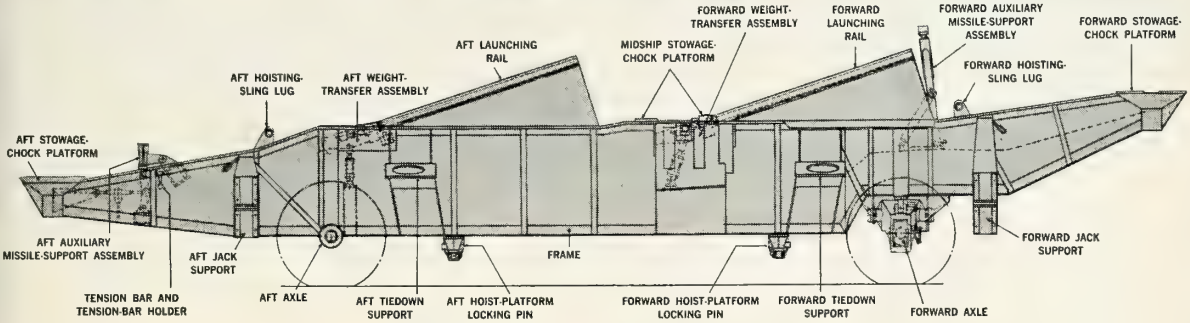
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Designed and built by Loewy-Hydropress, this vehicle will stow, transport and launch guided missiles from Navy cruisers. As a handling vehicle, the "Dolly Launcher" will cradle and protect the missile against all shock loads imposed by the ship and during stowage and transfer to the launching-training hoist.

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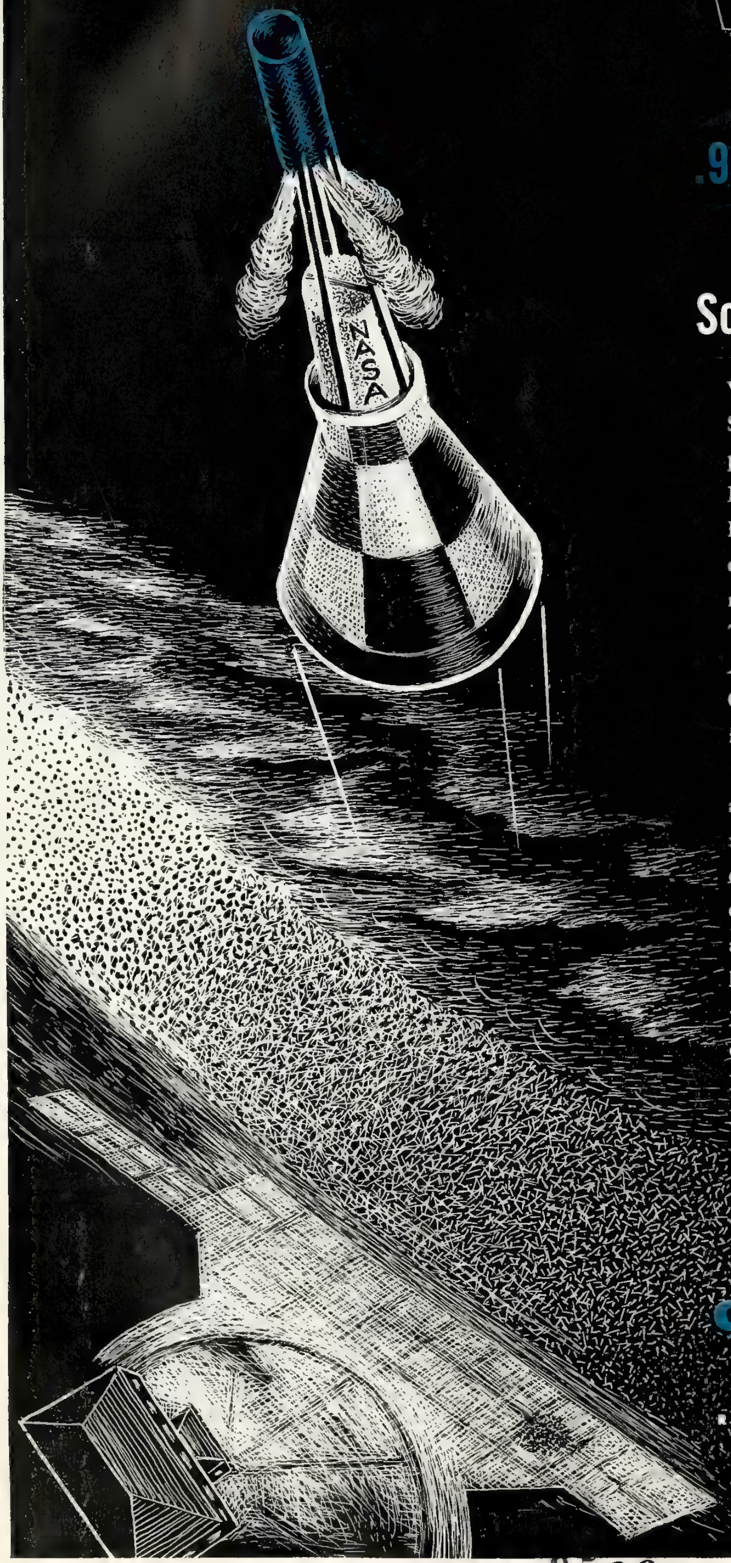

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